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ARTICLES

RELATIVE EFFECTIVENESS OF SEVERAL INSECTICIDES AS
SPRAYS AND AS FOGS AGAINST SALT-MARSH
MOSQUITO ADULTS¹

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For the last several years most of the mosquito-control districts in Florida have placed greater emphasis on the control of adults than on the control of larvae. Airplanes are widely used in large or inaccessible areas, but most of the districts rely mainly upon ground spray and fog machines for control of adults in towns and rural communities. Such machines are more economical than airplanes for small-scale work, are less limited in use in unfavorable weather, and have the added advantage of being usable day or night. However, little or nothing was known of the relative efficiency of some of the newer types of ground equipment, particularly under different conditions of use. Extensive field tests were therefore conducted in 1951 and 1952 to compare the performance of several types of spray and fog machines when applying different insecticides against the salt-marsh mosquitoes *Aedes taeniorhynchus* (Wied.) and *solicitans* (Wlkr.). The results obtained in these studies are presented in this paper.

TYPES OF EQUIPMENT.—In 1951 tests were conducted with an old-model Hession Microsol mist sprayer, a Dyna-Fog generator, and a jeep-operated mist sprayer developed by Husman (1953). In 1952 a new-model Hession Microsol, a Lawrence Aero-Mist L-40 sprayer, a small Japanese Kyoritu fog machine, and a skid-

mounted adaptation of the jeep sprayer were used.

The Hession Microsol is a self-powered unit which atomizes insecticidal solutions by means of multiple rotating disks and disperses them by an air blast from a turbine. The Lawrence Aero-Mist is a conventional type of hydraulic mist sprayer, in which the solution is forced through nozzles under low pressure and dispersed in a strong air blast. The jeep sprayer atomizes the solution by the shearing action of compressed air on the solution as it is forced through fine pneumatic nozzles. The unit is not equipped with a blower; so dispersal of the spray is dependent upon the wind. Each of these machines was calibrated to disperse 30 gallons of insecticidal solution per hour.

The Kyoritu fog machine is a small, self-powered unit in which the insecticidal solution is sprayed into the hot exhaust pipe and transformed into smoke or fog. A blower attachment on the exhaust disperses the smoke. With the Dyna-Fog the solution is injected into a jet tube, transformed into smoke, and dispersed in the powerful jet exhaust. The Dyna-Fog was calibrated to deliver 30 gallons per hour, but the Kyoritu was capable of dispersing only 6 gallons per hour.

The size of particles produced by the Microsol and jeep sprayers or the Dyna-Fog generator was not determined in 1951, but this information was obtained for all the machines before the field tests were begun in 1952. Data were obtained from measurements on magnesium oxide-coated slides exposed 50 feet downwind from each machine. The results are given in Table 1. Droplets smaller than 5

¹ This work was conducted under funds allotted by the Department of the Army to the Bureau of Entomology and Plant Quarantine.

² The writers acknowledge the advice and direction of W. V. King and W. C. McDuffie in this work, and the cooperation of W. D. Reed and Austin W. Morrill, Corps of Engineers, U. S. Army, in supplying part of the equipment.

TABLE 1.—Size of particles produced by the four types of spray or fog machines.

Machine	Percent of particles of indicated diameter (microns)				Diameter averages (microns)		
	5-40	41-80	81-120	121+	Median	Mass median	D ₀ ¹
Jeep sprayer	71	29	..	..	39	51	60
Hession Microsol	40	40	18	2	74	104	115
Lawrence Acro-Mist	70	16	6	8	46	160	107
Kyoritu	42	50	8	..	52	72	84

¹ D₀ is the diameter in microns of a drop with the same ratio of surface to volume as a representative sample of the drops in the spray.

microns were not included, as they do not produce distinct craters. With the Kyoritu fog machine probably most of the droplets were below this size.

MATERIALS AND DOSAGES.—The following insecticides were tested in fuel oil solution at the concentrations indicated:

1951

Lindane 2.5%
Dieldrin 5%
DDT 10%

1952

Heptachlor 2.5%
BHC (40% gamma) 2.5% gamma
Chlordane 5%
Dieldrin 5%
DDT 5%

Cyclohexanone was used as an auxiliary solvent for lindane, BHC, and dieldrin, and a hydrocarbon solvent for DDT.

All the insecticides were applied with each machine at rates of 6, 12, and 24 gallons per mile. Heptachlor and BHC were also tested at 3 gallons per mile. These rates of application were obtained by varying the speed of the vehicles on which the sprayers were mounted, not by altering the rate of dispersal. On the basis of an effective swath of 100 yards, the approximate pounds of insecticide per acre for different concentrations and rates of dispersal may be calculated as follows:

Gallons per mile	10%	5%	2.5%
3	0.07	0.04	0.02
6	.14	.07	.04
12	.28	.14	.07
24	.56	.28	.14

TEST PROCEDURES.—All the tests in 1951 and about half those in 1952 were conducted in orange groves near salt marshes in the Mims and Shiloh districts of Brevard County, Fla. The remainder of the tests in 1952 were made in typical wooded areas in northern Volusia and

southern Flagler Counties. Test plots were selected where mosquitoes occurred in annoying numbers and where roads were suitable for slow travel. Test plots for three of the machines were ¼ mile in length, but for the small Kyoritu they were only 100 yards long because of its low rate of dispersal.

Spraying and fogging operations were begun before sunrise and continued as long as inversion conditions persisted. The 1951 tests were conducted in winds ranging from 1 to 15 miles per hour, but in 1952 all tests were run in winds of less than 1½ miles per hour. After the machines were set in operation, the carrying vehicles were driven at a predetermined speed along the upwind side of the test plot so that the spray drifted into the area.

Mosquito populations were determined

by counting those landing on each of two men in 1 minute at ten stations in each plot. The stations were arranged in two lines of five each, 50 feet apart, perpendicular to the line of dispersal and near the center of the plot. Only five stations along a single line were set up in the Kyoritu plots. Counts were made on the afternoon before treatment and again 6 or 10 hours after treatment. Counts were also made regularly in untreated areas to determine whether any change in the treated plots was due to the treatments or to natural factors.

RESULTS. Tests in 1951.—In 1951 the 2- and 10-hour posttreatment counts were so nearly alike that either one could be used in evaluating the effectiveness of the different treatments and machines. In most of the tests slightly greater reductions were indicated by the 2-hour counts, but the difference was never more than 13 percent and seldom more than 10 percent. Since the counts were so closely comparable, only those made 2 hours after treatment are considered in the discussion. Results based on these counts are given in table 2.

The effectiveness of the insecticides varied somewhat with the rate of application, the type of machine, and the wind velocity. However, on the basis of the actual amount of insecticide applied, lindane was slightly more effective than dieldrin, and both were more effective than DDT. Specifically, applications of 2.5 percent of lindane solution gave equal or slightly better reductions in adult populations than applications of 5 percent of dieldrin, and both gave greater reductions than 10 percent of DDT.

With the Microsol mist sprayer 2.5 percent of lindane and 5 percent of dieldrin gave similar results at each rate of application. Lindane and dieldrin also gave comparable reductions at medium and high rates of application with the jeep sprayer, but lindane was superior at the lowest test dosage. With the Dyna-Fog generator lindane was more effective than dieldrin or DDT, which were about equal. No differences in the effectiveness of high, medium, and low dosages of lindane and DDT were indicated in the tests with the jeep sprayer, but with the

TABLE 2.—Effect of type of machine, wind velocity, and rate of application on the reduction of mosquitoes obtained with lindane, dieldrin, and DDT in oil solutions.

Wind velocity (m.p.h.)	Percent reduction with indicated gallons per mile								
	Lindane (2.5%)			Dieldrin (5%)			DDT (10%)		
	6	12	24	6	12	24	6	12	24
Microsol sprayer									
1-5	55	82	83	68	86	78	57	55	69
5-10	91	95	100	89	90	97	79	90	88
10-15	89	87	89	88	88	91	71	90	86
Average	78	88	91	82	88	89	69	78	81
Dyna-Fog generator									
1-5	95	95	96	80	69	88	88	87	91
5-10	75	66	80	72	64	58	50	30	62
10-15	28	25	54	12	24	56	28	37	51
Average	66	62	77	55	52	67	55	51	68
Jeep sprayer									
1-5	57	47	58	51	68	71	22	26	23
5-10	84	88	92	60	79	93	83	92	85
10-15	96	97	100	72	86	95	88	91	93
Average	79	77	83	61	78	86	64	70	67

other two machines the highest dosage caused the greatest reduction.

The best results with the Microsol sprayer were obtained when the wind velocity was 5 to 10 miles per hour, and the poorest at 1 to 5 miles. The jeep sprayer gave the best results at 10 to 15 miles per hour, and poor results at 1 to 5 miles, presumably because light breezes failed to disperse the spray particles. On the other hand, the Dyna-Fog generator was very effective at 1 to 5 miles per hour, and relatively ineffective at 10 to 15 miles. These results suggest that the fine particles of insecticidal fogs are of little value if dispersal is swift. This confirms the results obtained in Alaska in 1950, which indicated that fogs were most effective when they dispersed slowly and near the ground.

Tests in 1952.—Results of the tests in 1952 are presented in table 3. BHC was the most effective insecticide followed in order by heptachlor, DDT, dieldrin, and

chlordane. With few exceptions a BHC solution at 6 gallons or more per mile showed excellent control at both the 2- and 6-hour counts. Heptachlor gave rather poor immediate control except at the highest dosage, but showed excellent results after 6 hours. In most of the tests the highest dosage of DDT caused 90 percent or higher reductions within 2 hours, but lower dosages gave erratic and generally unsatisfactory control. Dieldrin was generally slightly less effective than DDT at corresponding dosages, but good control was indicated after 6 hours in plots treated at a rate of 24 gallons per mile with the Aero-Mist and Microsol sprayers. Chlordane was the least effective insecticide tested, the highest dosages giving only fair control.

There was little consistent difference in effectiveness between the various machines at wind speeds of less than $1\frac{1}{2}$ miles per hour, which prevailed throughout the tests. All gave about equally good re-

TABLE 3.—Percent reduction of mosquitoes 2 and 6 hours after dispersal of various insecticides with four types of machines, 1952. (2 to 5 tests.)

Insecticide and gallons per mile	Aero-Mist		Microsol		Jeep sprayer		Kyoritu	
	2 hours	6 hours	2 hours	6 hours	2 hours	6 hours	2 hours	6 hours
Heptachlor 2.5%								
3	58	36	16	44	..	..	71	82
6	22	77	78	92	72	96	49	74
12	48	99	60	100	56	99	30	85
24	61	99	94	100	86	100	89	98
BHC 2.5% gamma								
3	38	50	45	77	..	..	32	32
6	92	99	88	98	0	..	83	98
12	98	99	95	100	0	..	78	99
24	98	100	100	99	57	100	97	99
Dieldrin 5%								
6	39	55	18	71	27	45	70	68
12	45	55	29	66	60	73	71	90
24	51	90	43	93	76	82	71	62
DDT 5%								
6	80	73	40	66	59	56	79	78
12	80	80	17	75	63	64	96	85
24	93	95	82	93	90	91	98	82
Chlordane 5%								
6	41	60	18	78	31	78	13	55
12	48	62	48	98	5	35	26	68
24	60	82	57	85	58	64	28	70

sults with heptachlor and BHC. There were slight differences with the other insecticides, but these are not considered significant.

SUMMARY.—Extensive field tests were conducted in 1951 and 1952 to compare the performance of several types of spray and fog machines when applying different insecticides against adults of the salt-marsh mosquitoes *Aedes taeniorhynchus* (Wied.) and *sollicitans* (Wlkr.).

In 1951 lindane was slightly more effective than dieldrin and both were superior to DDT regardless of the type of equipment used. A fog machine (Dyna-Fog) gave the best results when winds were less than 5 miles per hour and the poorest at wind speeds over 10 miles, whereas the reverse was true with a jeep-operated mist

sprayer. A Hession Microsol sprayer was most effective at wind speeds of 5 to 10 miles per hour.

In 1952 BHC (40% gamma) was slightly more effective than heptachlor, and both were considerably better than DDT, dieldrin, and chlordane. There was little consistent difference in effectiveness between the Lawrence Aero-Mist, Hession Microsol, and jeep sprayers and a Kyoritu fog machine at wind speeds of less than 1½ miles per hour, which prevailed throughout the tests.

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TESTS WITH GRANULATED INSECTICIDES FOR THE CONTROL OF SALT-MARSH MOSQUITO LARVAE^{1, 2}

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Aerial spraying of insecticides frequently fails to give satisfactory control of the larvae of *Aedes taeniorhynchus* (Wied.) and *sollicitans* (Wlkr.) in salt-marsh breeding areas in Florida. Such treatments are ineffective largely because only a small proportion of the spray penetrates the vegetative cover and reaches the larvae in the water. The development of increased resistance in these species to the chlorinated hydrocarbon insecticides has further emphasized the need for getting adequate quantities of larvicide into the water.

In tests on the control of *Psorophora confinnis* (L.-Arr.) and *discolor* (Coq.)

in rice fields in Arkansas, Whitehead (1951) found that better penetration of thick stands of rice could be obtained by applying bentonite pellets coated with the larvicides. In view of the results, tests were made on salt marshes in Brevard County, Florida, to determine whether greater efficiency could be obtained with insecticides on granular carriers.

HAND APPLICATIONS.—Preliminary tests were conducted on small plots (100 to 7,000 square feet) with lindane, dieldrin, heptachlor, chlordane, TEPP, and parathion on granular bentonite, in comparison with emulsions of the same materials. All emulsions were applied at a concentration of 1 percent with a small hand atomizer. The granular bentonite containing 0.5, 1.5, and 5 percent of toxicant was broadcast by hand. The emulsions and granulated insecticides were applied in various amounts to give dosages of 0.01, 0.025, 0.05, and 0.1 pound of toxicant

¹This work was conducted under funds allotted by the Department of the Army to the Bureau of Entomology and Plant Quarantine.

²Presented at the meeting of the American Mosquito Control Association at Daytona Beach, Florida, April 12-17, 1953.

per acre. Their effectiveness was based on the difference in dipping counts of larvae before and 24 hours after application. Results of the tests are given in table 1.

and was more effective than chlordane. TEPP showed only slight toxicity at the highest test dosage of 0.1 pound per acre. At sublethal concentrations all the insecticides except chlordane were generally

TABLE 1.—Control of salt-marsh mosquito larvae with several insecticides applied by hand in granulated form and in emulsions. (Average of 2 replications.)

Insecticide and form	Percent of toxicant	Percent reduction at indicated dosage of toxicant per acre			
		0.1 pound	0.05 pound	0.025 pound	0.01 pound
Dieldrin:					
Granulated	0.5	..	99	100	86
	1.5	..	100	100	0
	5.0	..	100	88	40
Emulsion	1.0	..	100	100	93
Heptachlor:					
Granulated	.5	..	100	100	51
	1.5	..	100	94	10
	5.0	..	100	100	22
Emulsion	1.0	..	100	100	100
Parathion:					
Granulated	.5	..	100	74	29
	1.5	..	100	100	73
	5.0	..	100	100	91
Emulsion	1.0	..	100	100	86
Lindane:					
Granulated	.5	..	100	27	0
	1.5	..	99	53	27
	5.0	..	30	40	0
Emulsion	1.0	..	100	89	65
Chlordane:					
Granulated	.5	100	95	66	..
	1.5	99	100	32	..
	5.0	94	28	0	..
Emulsion	1.0	100	69	22	..
TEPP:					
Granulated	.5	31	21	0	0
	1.5	0	0	0	0
	5.0	0	0	0	0
Emulsion	1.0	49	0	0	..

Parathion, heptachlor, and dieldrin gave complete or nearly complete kills at a dosage of 0.025 pound per acre, in granulated form and in emulsions. Kills were somewhat erratic at the 0.01-pound dosage, parathion being slightly superior to dieldrin and heptachlor in the granulated form and slightly inferior in the emulsions. Lindane gave excellent control at 0.05 pound per acre except in one test,

more effective when applied in emulsions than in granulated form. As the breeding areas were fairly open, there was little difference in the amount of toxicant that reached the water surface; so the difference in results is attributable to more uniform dispersion of the emulsion.

Additional tests were made to compare granulated insecticides containing dieldrin, heptachlor, EPN, chlordane, or DDT as

the toxicant and attapulgit or bentonite as the carrier. The granules were impregnated with 5 percent of insecticide and were broadcast by hand in the amounts necessary to give dosages ranging from 0.01 to 0.1 pound of toxicant per acre. The results are shown in table 2.

centration on 16/30-mesh bentonite. Heptachlor and dieldrin were tested at 2.5-percent concentration on 30/60-mesh attapulgit. BHC (40 percent gamma isomer) was used at a concentration of 1 percent of gamma isomer on tobacco stems and at 5 percent on bentonite. The

TABLE 2.—Control of salt-marsh mosquito larvae with hand applications of several granulated insecticides with attapulgit and bentonite as the carriers. (Average of 2 replications.)

Insecticide	Dosage (pound per acre)	Percent reduction in 24 hours	
		Attapulgit	Bentonite
EPN	0.01	30	84
	.025	95	100
	.05	96	100
	.1	99	100
Dieldrin	.01	72	22
	.025	19	77
	.05	67	93
	.1	96	100
Heptachlor	.01	99	74
	.025	99	66
	.05	82	97
	.1	92	99
Chlordane	.01	7	53
	.025	71	16
	.05	93	98
	.1	87	98
DDT	.01	54	0
	.025	61	..
	.05	42	45
	.1	24	74

EPN was the most effective material tested, followed in order by heptachlor, dieldrin, chlordane, and DDT. All the insecticides were more effective with bentonite than with attapulgit at the practical dosages of 0.05 and 0.1 pound per acre. At lower dosages the results were somewhat erratic, particularly with attapulgit, and no clear-cut difference between the two carriers was apparent.

AERIAL APPLICATIONS.—Large-scale tests on typical pickleweed salt marshes were conducted to compare the effectiveness of 10 insecticides prepared with various granular carriers applied by airplane. EPN, parathion, heptachlor, dieldrin, aldrin, chlordane, toxaphene, malathion, and DDT were used at a 5-percent con-

materials were applied at rates of 1 to 5 pounds per acre.

All applications were made with a Stearman airplane flying at a speed of 80 miles per hour and at an altitude of 75 feet. The plane was equipped with a belly tank duster, which had been modified to apply granulated materials. The unit could be adjusted to deliver 1 to 5 pounds per acre, but was not entirely satisfactory because the effective swath was only about 20 feet.

Applications were begun early in the morning and continued throughout the day. Meteorological conditions were generally unfavorable, as high winds of about 25 miles per hour persisted throughout the period of application. The effects of

the wind were offset to some extent by flying with and against it. However, even then it would have been impossible to apply sprays or dusts satisfactorily. The results of these tests are shown in table 3.

weed, mangrove, or other vegetative cover. Tests have indicated that at least 50 percent of the spray fails to penetrate the moderate densities of pickleweed and to reach the water. Thus, in aerial spray-

TABLE 3.—Effectiveness of aerial applications of several granulated insecticides against salt-marsh mosquito larvae.

Insecticide	Carrier	Dosage (pounds per acre)		Pretreatment count	Percent reduction in 24 hours
		Granules	Toxicant	Larvae per dip	
EPN	Bentonite	1	0.05	94	98
Parathion	do.	1	.05	68	97
Heptachlor	do.	1	.05	36	95
	Attapulgit	2	.05	17	88
BHC (gamma)	Tobacco stems	5	.05	10	91
	Bentonite	1	.05	33	90
Dieldrin	do.	1	.05	44	89
	Attapulgit	2	.05	22	0
Toxaphene	Bentonite	2	.1	23	89
Malathion	do.	4	.2	12	88
Aldrin	do.	2	.1	47	87
Chlordane	do.	4	.2	14	81
DDT	do.	4	.2	111	76

Applications of 0.05 pound per acre of EPN, parathion, and heptachlor on bentonite gave nearly complete kills of larvae. Dieldrin and BHC on bentonite and BHC on tobacco stems were only slightly less effective at this dosage. Toxaphene and aldrin on bentonite at 0.1 pound and malathion at 0.2 pound gave reductions of 87 to 89 percent, and were somewhat more effective than chlordane and DDT at 0.2 pound per acre. Heptachlor was slightly less effective on attapulgit than on bentonite. Dieldrin on attapulgit was completely ineffective, but the reasons for the poor results were not determined.

DISCUSSION.—Excellent control of salt-marsh mosquito larvae can be obtained with low dosages of insecticides applied by hand, but in aerial spraying of typical salt marshes higher dosages are usually necessary to compensate for the loss of spray through impingement on pickle-

weed, mangrove, or other vegetative cover. Tests have indicated that at least 50 percent of the spray fails to penetrate the moderate densities of pickleweed and to reach the water. Thus, in aerial spray-

These tests indicate that granulated insecticides have exceptional possibilities for treating salt-marsh breeding areas having heavy vegetation. Not only do they insure penetration of vegetative cover and proper coverage of such areas, but they

permit successful application under meteorological conditions in which aerial spraying or dusting would be useless. These advantages are offset to some extent, however, by the fact that applications must be made in narrow swaths to insure proper coverage; thus the flying time necessary to treat a given area is three to five times as long as in spraying. Better equipment for planes should provide a wider swath, but it is unlikely that the swath can be increased to more than half that obtained with sprays.

SUMMARY.—Field tests were conducted in Brevard County, Florida, to determine whether effective control of larvae of *Aedes taeniorhynchus* (Wied.) and *solicitans* (Wlkr.) in salt-marsh breeding areas having heavy vegetation could be obtained with various granulated insecticides applied by airplane.

In preliminary tests with hand applications parathion, heptachlor, and dieldrin were highly effective at a dosage of 0.025 pound per acre, both in emulsions and on granular bentonite. Similar results were obtained with lindane at 0.05 and chlordane at 0.1 pound per acre, but TEPP showed only slight toxicity at these dosages. In additional tests with attapulgit and bentonite granules, EPN was effective at 0.025 pound per acre, and heptachlor, dieldrin, and chlordane at 0.05 or 0.1 pound. DDT gave relatively

poor control at 0.1 pound per acre. At these dosages all the insecticides were slightly more effective with bentonite than with attapulgit, but at lower dosages no clear-cut difference between the two carriers was apparent.

In tests on typical pickleweed marshes aerial applications of 0.05 pound per acre of EPN, parathion, and heptachlor on bentonite gave nearly complete kills of larvae, and were slightly more effective than similar applications of dieldrin or BHC on bentonite or of BHC on tobacco stems. Toxaphene and aldrin at 0.1 pound and malathion at 0.2 pound gave nearly 90-percent control, and were slightly more effective than chlordane and DDT at 0.2 pound per acre. Heptachlor was less effective on attapulgit than on bentonite. Dieldrin on attapulgit was ineffective.

Results of these tests indicate that the aerial application of granulated insecticides in salt marshes with heavy vegetation is more effective than spraying, and has exceptional possibilities in practical operations under Florida conditions.

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MOSQUITO DISTRIBUTION IN ALASKA WITH ESPECIAL REFERENCE TO A NEW TYPE OF LIFE CYCLE

WILLIAM C. FROHNE¹

26

The most important and best known family of Alaskan insects is the Culicidae, or mosquitoes. Northern mosquito investigations since World War II have provided enough insight into the Alaskan distribution, if not yet furnishing an adequate check list, to be of interest to other entomologists and even make contributions to biogeography. In this paper it is proposed to compare in a general way arctic, subarctic, and temperate zone mosquito faunas. Disregarding several rare species and those of uncertain occurrence as well as transition elements which tend to obscure zonal distinctions, lists of the mosquitoes of Umiat, Anchorage, and Juneau have been chosen to represent their respective zones. This procedure introduces a considerable error of omission, but it does not seem either to misrepresent zones or to affect the chief conclusions. Unfortunately, we cannot yet draw up complete lists of arctic, subarctic, or temperate zone Alaskan insects.

At first glance, today's list of Alaskan mosquitoes²—about 24 species belonging to the worldwide genera *Aedes*, *Culiseta*, *Culex*, and *Anopheles*—appears commonplace enough to resemble another State check list. Nothing could be farther from the truth, however, for when these species are viewed with a biological bias they are seen to constitute an extraordinary assemblage of cold-tolerant forms, a rigorous selection biota, having a good deal in common biologically. It is evident that

Alaskan mosquitoes manifest only one of four types of life cycles represented by mosquito biologies in temperate United States or Europe, and that the biologies of three-quarters of the species belong to this one type of cycle which therefore thoroughly predominates in Alaska. The type of life cycle of the remaining several species is a new one (Frohne, 1953) characteristic of the subarctic. Thus not only has the northern environment selected species similarly qualified to survive the winter and to take full advantage of the short summer, but it has even developed, by a kind of convergent adaptation, a second type of strictly northern life cycle for the several other species whose phylogenies required them to hibernate in a different life-history stage. Furthermore, when the three zonal lists of mosquitoes are presently contrasted, it will be noted that only the dominant type of life cycle occurs in the arctic list, and that the other type, starting from a subarctic origin, becomes relatively less important in temperate southeastern Alaska.

Trees are an important part of the environment to mosquitoes, and their distribution is also an important biological difference between the three life zones. The convenient custom of mosquito workers of designating species which are apparently limited to forests as "woods" species, and those of treeless country as "tundra" or "prairie" species, is followed here. Admittedly, nevertheless, only better distribution data and careful life-history studies showing how trees may be necessary, perhaps for mating activities or for hibernation of "woods" mosquitoes, can establish the validity or erroneousness of these handy, speculative designations.

TYPES OF CYCLE.—Four kinds of mosquito life cycles have been recognized, (Bates, 1949) depending chiefly on the number of broods per year and the stage

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² *Aedes aboriginis*, *cataphylla*, *cinereus*, *communis*, *diantaeus*, *excrucians*, *fitchii*, *flavescens*, *hexodontus*, *impiger*, *intrudens*, *nearcticus*, *nigripes*, *pionips*, *pseudodiantaeus*, *pullatus*, *punctodes*, *puncator*; *Anopheles* ? *occidentalis*; *Culex territans*; *Culiseta alaskensis*, *impatiens*, *incidens*, *macrackenae* ?, and *morsitans*.

in which the inclement season (winter or dry season) is passed. Each type, originally proposed by Wesenberg-Lund, has been named by Bates after a typical, representative species. Thus, in the one named for the almost cosmopolitan house mosquito—the *Culex pipiens* type of life cycle—there are an indefinite number of broods a season, and it is the inseminated females which hibernate. This type of cycle does not occur among Alaskan mosquitoes. As a matter of fact, no Alaskan mosquitoes appear to have more than a single annual brood. Three-fourths, probably eighteen, of the Territory's species belong to the *Aedes cinereus* type of life cycle, which is single-brooded, with hibernation in the egg. Disregarding a peculiar species of *Culiseta* (which may possibly hibernate in the larval stage in Alaska as it does in Europe), since we do not know the facts, the remaining species (about 5) cannot be accommodated in any of the long recognized types of life cycle. Every Alaskan is familiar with some of these common mosquitoes, which include the large biters of early spring. One of them is a winter mosquito, frequently encountered by snowshoers on the trails about Juneau, flying in the sunshine and resting on the snow in January and February. It was the detailed study of two species of this group by entomologists of the Arctic Health Research Center which led to the definition and naming of this new type of cycle—the *Culiseta impatiens* type of life cycle. Before discussing the distribution of Alaskan mosquitoes according to type of cycle it is desirable to characterize the two cycles of Alaskan mosquitoes.

Aedes cinereus TYPE OF CYCLE. *Aedes cinereus* itself and about 17 congeners are the well-known, vicious biters of June and July in Central Alaska. Most of them are smaller kinds than the big *Culiseta* pests of April and May which they replace, but their numbers are legion. They begin biting just after they have finished mating, usually in characteristic swarms. They seek blood in order to develop the eggs, which they soon lay individually in

the dry basins of vernal snow-melt pools. The eggs develop embryos at once, but they do not hatch, even if inadvertently flooded. Instead, they lie quiescent over the winter until with the melting snows of the following spring, they hatch in a characteristic order or succession according to species. Thus the earliest abundant one, *Aedes communis*, is typical of cold melt holes of partly ice-bound pools, while a late one, *Aedes pionips*, occurs especially in lukewarm pools a month or more later. *Aedes cinereus* is intermediate. Regardless of minor differences of hatching habits and of habitat, the adults emerge about a month afterwards. They mate, soon bite, and oviposit to complete the cycle. Thus, *Aedes cinereus* and all other Alaskan *Aedes* species pass 8–10 months of their individual lives of about a year as embryonated eggs, and they produce one annual brood.

Culiseta impatiens TYPE OF CYCLE. Besides *Culiseta impatiens*, *C. alaskaensis*, (Frohne, 1954) has been shown to pass through a closely similar life cycle, and it is necessary to assume from larval dipping records and other evidence that the local species of *Culex* and *Anopheles* also manifest similar life cycles. The eggs of *C. impatiens* are laid in May or June in boat-shaped rafts of a hundred or more eggs directly on the water of permanent ponds and bog pools. After 5 days they hatch and rush through their larval and pupal development to the winged stage in less than a month. Mating is probably always without the formalities of male swarms, and the males die soon afterwards. The inseminated females are restless and without bloodlust during their first summer. They seek out resting places where they may remain dormant as long as 9 or 10 months. In southeastern Alaska, however, they come forth impatiently on sunny days of winter. In March, April or May they seek blood, mature the eggs in about two weeks, oviposit, and so complete the cycle. Part of a female's activities belong to her first summer, another kind of behavior to her second summer, and she is likely to live

more than a year as an adult insect. The occurrence of two types of females with quite dissimilar habits led to disagreements as to biting behavior of these species until the life histories were worked out. Of the other mosquitoes with this cycle, the Alaskan *Anopheles* similarly bite only after hibernation, but the *Culex* do not bite man. In fact, nothing is known of the biting habits of *Culex territans* in Alaska. The essential features of the *Culiseta impatiens* type of life cycle are single-broodedness and hibernation by the inseminated female.

ARCTIC MOSQUITOES. Knight (1948), to whom we owe the list of Umiat mosquitoes, reported three species and evidence for the occurrence of one or two more there. Mosquitoes are exceedingly abundant and troublesome at Umiat. The known species are *Aedes punctor*, *communis*, and *nearcticus*. The suspected additional ones are closely related *Aedes* species such as *A. nigripes*. All of these belong to the *Aedes cinereus* type of cycle. Even though *punctor* and *communis* occur in forests farther south, all these arctic forms must be considered "tundra" species, for trees in the usual sense do not occur about Umiat. Some or perhaps all of them are great migrants here. Their dispersal with the wind has been observed by others and ourselves in the strange light of arctic evening. This phenomenon of dispersion has been called upon to explain the short duration of mosquito abatement when about 30 square miles around Umiat were sprayed with DDT concentrate by aircraft. It may be a result of the almost continuous sunlight of the flight period that these arctic mosquitoes manifest no noticeable periodicity in biting and perhaps of other activities. The mosquito biting season in this part of the arctic is less than a month per year, but it is possibly the most severe in the world during this short period.

SUBARCTIC MOSQUITOES. The Anchorage area has a larger and better known mosquito fauna.¹ There occur at least four species with the *Culiseta impatiens* and twelve with the *Aedes cinereus* types

of cycle. (The cycle of *Culiseta morsitans* is in doubt.) Two of the former group of species, unfortunately, are bad pests of the early springtime. This results in extending the mosquito biting season, which lasts about four months. The latter group includes some "woods" mosquitoes, a salt-marsh contingent, of which *Aedes punctodes* is most important, and several kinds which avoid trees. Their adult habitats are neither tundra nor prairie. One of these "non-woods" species which breeds only in brackish water in Alaska, so far as is known, is *Aedes flavescens*. The adults of *flavescens* do not leave the open salt meadows. Of even greater practical importance is the behavior of biting females of certain "woods" species which are not merely reluctant to leave the cover of the trees but actually do not molest people living in large clearings. The same species, in the main, do not disperse far from their breeding areas, although "far" may mean more than a mile. Unfortunately, away from the coast and further north such fortunate habits, or the species manifesting them, are less prominent when evident at all.

TEMPERATE ZONE ALASKAN MOSQUITOES. Any attempt to explain biogeography of southeastern Alaska should take into account the recent recession of the ice cap there and the comparative isolation still caused by sea, ice, and mountain barriers. However, radiocarbon dating, (Berrill, 1953), shows no such great age difference from the north temperate United States as one might expect. Much of Maine was still covered by the last continental glacier for about a thousand years after the bog on upper Montana Creek near Juneau melted and began accumulating peat about 5,000 years ago as Heusser (1952) has determined. But this geologically short period operated in conjunction with sea and mountain barriers and lengthy if mild winters in southeastern Alaska, and

¹ *Aedes cataphylla*, *cinereus*, *communis*, *dian-taus*, *excrucians*, *fitchii*, *flavescens*, *impiger*, *intrudens*, *pionips*, *punctor*, *punctodes*; *Anopheles* ? *occidentalis*; *Culex territans*; *Culiseta alaskensis*, *impatiens*, and *morsitans*.

the combination of impediments has apparently kept many organisms out to this day. Some mosquitoes, e.g. *Culiseta alaskaënsis* and *Aedes excrucians*, have apparently penetrated into the region only at points like Haines and Wrangell where major rivers provide an avenue from the interior. However, along the coast and perhaps by island-jumping came two mosquitoes, *Culiseta incidens* and *macracantha*? which are otherwise typical United States West Coast temperate forms. A further factor is the cool summer climate of southeastern Alaska. The region is relegated to the temperate zone in recognition of its mild winters, despite its cool summer climate, as a glance at July and January isotherm maps for North America makes obvious.

Viewed in the light of the preceding paragraph it is not surprising that the Juneau list of mosquitoes,¹ representing southeastern, i.e. temperate Alaska, resembles the arctic and subarctic Alaskan lists more than it would a stateside temperate zone list of mosquitoes. At Juneau eight species with the *Aedes cinereus* type of cycle and two with the *Culiseta impatiens* occur. There are no mosquitoes which produce more than a single annual brood though the mosquito biting season is very long, over five months. The absence of *Culex* and *Anopheles* suggests the arctic list. It is probably too cool in summer about Juneau, as at Umiat, for the sun-loving malaria mosquito. The maritime influence is apparent in the predominance as a pest of *Aedes punctodes*, a salt-marsh species. This species probably immigrated from the subarctic along the coast. As has been noted for some subarctic coastal

mosquitoes (*Aedes*), those of southeastern Alaska are probably all "woods" species which disperse relatively short distances and leave the shelter of the forest reluctantly.

SUMMARY AND CONCLUSION. A preliminary check list of 24 Alaskan mosquitoes, and three partial lists representing arctic, subarctic, and temperate life zones of the Territory are presented. After viewing these lists of species according to their biologies—types of life cycles—it is concluded that Alaskan mosquitoes as a whole are an extraordinary selection biota. Only two types of life cycle, both manifestly adaptations to the northern climate, occur. One of these, which is especially characteristic of the subarctic, is new. All Alaskan mosquitoes are single-brooded. They may be classified as to type of life cycle by the stage, egg or inseminated female, which hibernates. Biological differences among the representative species lists of the three zones are discussed. Of practical importance is the length of the mosquito biting season, less than a month in the arctic, about 4 months in the subarctic, and more than 5 months in temperate Alaska.

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¹ *Aedes aboriginis*, *cinereus*, *communis*, *impiger*, *pionips*, *pullatus*, *punctodes*, *punctor*; *Culiseta impatiens*, *incidens*, *morsitans*.

INSECT PREDATORS OF MOSQUITO LARVAE AND PUPAE IN ALASKA¹

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Numerous instances of insects attacking and feeding on mosquito larvae and pupae came to the attention of the authors during the summer of 1948 as they engaged in a study of the biology of Alaskan mosquitoes. Many studies concerning predators of the immature stages of mosquitoes have been conducted in other parts of the world; however, the only information based on observations in Alaska is that given by Jenkins (1948). He noted that predaceous Chaoborinae were locally abundant and that other types of predaceous insects were common in the latter part of the breeding season.

The results of the observations made by the authors during 1948 are discussed below.

DYTISCIDAE (COLEOPTERA). Laboratory observations at Fairbanks demonstrated both larvae and adults of the genus *Agabus* to be effective mosquito predators. One larva was kept in the laboratory for 20 days before it died. During this time it destroyed 80 mosquito larvae and 10 pupae. This and one other *Agabus* larva molted twice during captivity; one larva molted 3 days after being brought into the laboratory and again 4 days later. During the period between molts one larva destroyed 10 second- and third-stage *Aedes* larvae, and the other disposed of

11. No *Agabus* larvae pupated, but the cause of their death is not known. One *Agabus* adult consumed 63 *Aedes* larvae in 13 days.

Many other adult and larval dytiscids were observed to feed on mosquito larvae. In the field dytiscid larvae were frequently captured still holding wigglers in their mandibles. Larvae were numerous and widely distributed, particularly in semipermanent water (pools that became dry sometime during the season). Except for chaoborines, the dytiscids seemed to be the only predators that were associated to any extent with larvae of the early-maturing, black-legged *Aedes*.

CORIXIDAE (HEMIPTERA). Since 1905 several authors have reported various species of Corixidae to be predaceous on mosquito larvae (Hinman 1934, Hale 1922, Poisson 1935), and in 1947 Jenkins (unpublished report) listed corixids as incidental predators in Alaska. Despite these observations the view has persisted among most entomologists that the predaceous habit is incidental and that most corixids feed primarily on diatomaceous ooze, flocculent organic matter, and algae. A possible exception is the genus *Cymatia*, which appears to be structurally adapted for predaceous habits.

It was therefore something of a surprise when on May 1 a mating pair of *Calli-corixa audeni* Hungerford was observed to feed on *Aedes* larvae to the exclusion of other food. The corixids were brought into the laboratory in a pint jar containing some pond vegetation, some bottom ooze, and 25 larvae of *Aedes communis* (De-

¹ These observations are based on material and data collected by the authors while they were members of the Alaska Insect Project in 1948. This project was conducted by the U. S. Bureau of Entomology and Plant Quarantine under a transfer of funds from the Department of Defense to the Bureau.

Geer). Both the corixids and the wigglers seemed contented; however, the jar was not watched closely during the next 5 days. By May 6 all the wigglers had disappeared, leaving remains that looked like cast skins, and the corixids were attempting to escape from the jar.

The corixids were then placed in a 4-ounce jar with three wigglers, and they again appeared satisfied. The following morning no wigglers were present in the jar, and three more were added with similar results. On May 8 three more wigglers were added and the jar was placed under close observation. Within 5 minutes the female corixid had seized a wiggler (fourth-instar *A. communis*). The wiggler was held by the forelegs and clasped tightly against the lower face. The stylets could be seen as they probed through the cuticle of the wiggler. The wiggler's struggles caused the corixid no difficulty and it was soon subdued. The corixid made the usual trips to the surface for air carrying the larva with it.

The male soon proceeded to feed at one end of the wiggler held by the female, which fed at the other end. Occasionally they would break apart, the female retaining the wiggler. After 20 minutes the wiggler was reduced to a collapsed skin, with even the head capsule caved in. Only the contents of the alimentary tract remained inside the wiggler. Shortly after the first wiggler was discarded, the male captured another and the procedure was repeated but at a much slower speed. The female joined in feeding on the wiggler only once for a period of 3 minutes. The male continued to feed for 55 minutes. At the end of this time the wiggler was reduced to an empty skin.

Later observations supported the conclusion that *Callicorixa audeni* and *alaskaensis* Hungerford are both predaceous on mosquito larvae. It is significant that the adult corixids were quite content to stay in jars as long as mosquito larvae were present, but were repeatedly observed trying to escape within 24 hours after larvae were no longer available. The presence of small crustaceans, plant life,

or bottom ooze did not remove their obvious dissatisfaction. These observations indicate that mosquito larvae are favored prey, and suggest that the adult *Callicorixa* may migrate from pools in which the mosquito population is exhausted.

Both species of *Callicorixa* were collected within an area extending from Anchorage and Valdez north to Circle City and east to the Yukon border. Both were frequently found in the same pools; however, *audeni* was more common in both number of individuals and number of collections.

Adults and nymphs were found in semipermanent pools that normally produce *Aedes excrucians* (Walker), *A. fitchii* (Felt and Young), *Anopheles carlei* Vargas, *Culiseta alaskaensis* (Ludlow), *C. impatiens* (Walker), and *Culex territans* (Walker). There seems little reason to doubt that these corixids are an important factor in limiting the abundance of these species of mosquitoes.

CHAOBORINAE (DIPTERA: CULICIDAE).² The predaceous larvae of this culicid subfamily were frequently encountered. The genus *Corethra* was more common than *Chaoborus* near Fairbanks, and larvae were often taken from pools containing larvae of *Aedes punctor* (Kirby) and the later developing *Aedes* species. *Corethra* larvae were also numerous in pools where *Culiseta* wigglers were found. *Corethra* larvae were also common near Anchorage, but seldom was more than one larva per selected dip found even in favorable locations.

At Anchorage two permanent ponds containing much emergent vegetation were observed to contain four to six larvae of *Chaoborus flavicans* (Meigen) per dip as early as April 19. Virtually no *Aedes* or *Culiseta* mosquitoes were produced in these ponds. *C. flavicans* larvae pupated about May 1 and adults emerged between May 5 and 7. Second and third instars were again common in the same pools after the middle of August.

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² Laboratory observations were made by Kathryn M. Sommerman.

The importance of *C. flavicans* as a predator on mosquito larvae was further confirmed by laboratory observations. On April 23 eight fourth-stage *flavicans* larvae were brought into the laboratory and placed in a jar with several first-stage *Aedes* larvae. The mosquito larvae disappeared and the supply was replenished at intervals. On April 28 one *flavicans* larva was isolated and placed under close observation. The isolation was made in the forenoon, and 10 first-stage *Aedes* larvae were placed in the rearing tube with the *flavicans* larvae. One wiggler was eaten immediately, tail first, and eight more were consumed during the day. Twenty-three more wigglers were eaten before the *flavicans* larva pupated on May 1. Five of the *flavicans* larvae in the general culture pupated on the same day. Records of the specimens in the general culture are incomplete; however, two adults emerged on May 5 and another on May 6. The isolated specimen emerged as an adult on May 7. Both in the general culture and in the case of the isolated specimen there was evidence that the *flavicans* larvae seized and killed many mosquito wigglers without eating them.

ODONATA. Damselfly and dragonfly naiads were abundant along marshy lake shores and in permanent ponds containing floating vegetation. These locations are particularly favorable for the development of *A. earlei* and *C. territans*. Early instars of these species as well as of the *Culiseta* species were frequently found in abundance. However, if one naiad per two or three dips could be found in the same water, no *Culiseta* and few *Anopheles* or *Culex* were observed to survive to the pupal stage.

DISCUSSION. No accurate assessment of the importance of the insect predators in controlling mosquitoes in Alaska is possible from these limited observations. Ob-

viously their presence does not prevent pest populations from developing in central and northern Alaska. However, it is quite possible that they restrict the period of time that annoying mosquito populations are present in an area and that they greatly reduce such populations locally during years when a generally distributed pest population is not produced.

This assumption is based on evidence that the generally distributed pest species develop in temporary snow-melt pools, which are not suitable for the immature stages of most of the predator species. On the other hand, the predators thrive in the semipermanent and permanent pools, where the less important species of *Aedes*, *Culiseta*, *Anopheles*, and *Culex* develop. The *Aedes* species originating in these pools emerge later than do the species of greatest pest importance and in local areas prolong the season of annoyance, whereas the *Culiseta* species live through the winter as adults and are capable of creating a serious nuisance several weeks in advance of the first *Aedes* emergence. If the natural check provided by the predators were removed, there is little doubt that the season of mosquito annoyance would be lengthened and that the pests would be much more numerous in localities adjacent to ponds and marshes.

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PICTORIAL KEYS TO THE MOSQUITOES OF MEDICAL IMPORTANCE¹

V. FRENCH INDOCHINA

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This is the fifth in a series of keys prepared primarily to help public-health workers separate and identify rapidly the mosquitoes of medical importance in various parts of the world. This series is being produced under a transfer of funds from the Department of the Army to the Bureau of Entomology and Plant Quarantine. The keys are so constructed that they separate the important species not only from each other but also from all others known to occur, or suspected of occurring, in the region. Suggestions and comments will be welcomed, especially from those with first-hand information about the faunas or diseases of the region.

Anopheles minimus is the chief vector of malaria in Indochina. It breeds typically at the edges of clear, slow-running, partly shaded streams, but has been found in clear water at the edges of swamps, rice fields and borrow pits. It is the most anthropophilic of the malaria vectors in Indochina, and its wide distribution in the extensive foothill regions makes it responsible for the most serious malaria problems in this country.

Anopheles jeyporiensis candidiensis is another foothill species, found typically in standing or running, grassy, clear water. It is less important as a vector of malaria than *A. minimus* because of its greater preference for non-human blood. *Anopheles maculatus* is a third species associated with hilly or mountainous country, breeding in many types of water collections,

and occurring in large numbers in newly cleared jungle areas. *Anopheles sinensis* is responsible for the transmission of a low-grade malaria, with occasional explosive outbreaks, in the flat rice-growing areas of the northern and southern delta lands. It often occurs in tremendous numbers, and breeding tends to increase with the clearing or cultivation of jungle areas. *Anopheles sudaicus* breeds almost entirely in brackish water along the southern coast of Indochina, where it is found in lagoons, swamps and salt-water fish ponds. It is less important than the foregoing species owing to its restricted distribution and its less definite anthropophilism. *Anopheles aconitus* has variable breeding habits, but is found most often in rice fields and fresh-water ponds in mountainous as well as in plains areas. It has been strongly suspected as a vector in South Annam. Throughout most of Indochina, however, its importance appears to be unpredictable, and it is regarded as a secondary vector.

Other *Anopheles* species and varieties known or assumed to be present in Indochina are *aikhenii aikhenii*, *aikhenii bengalensis*, *alongensis*, *annandalei annandalei*, *annandalei interruptus*, *baezui*, *barbirostris barbirostris*, *barbumbrosus*, *annularis*, *culicifacies*, *fluviatilis*, *jamesi*, *jeyporiensis jeyporiensis*, *karwari*, *kochi*, *leucosphyrus*, *litoralis*, *maculipalpis*, *pallidus*, *philippinensis*, *splendidus*, *stephensi*, *subpictus*, *tesellatus* and *vagus vagus*.

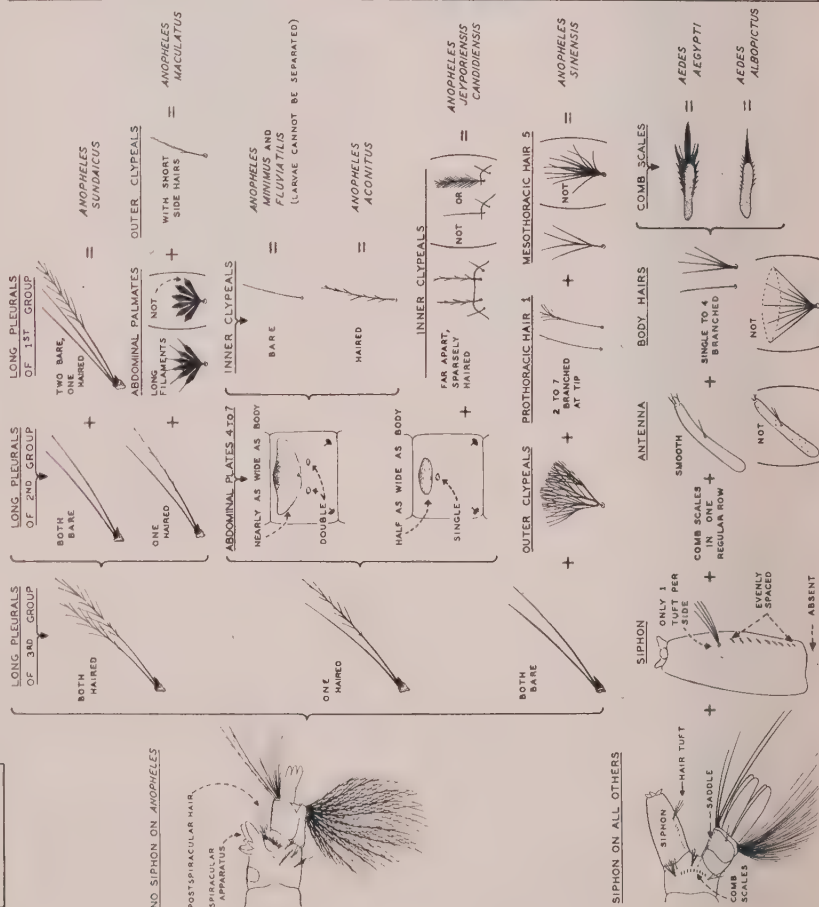
Approximately 90 non-anopheline species of mosquitoes have been recorded from this country. Of these, two are important in disease transmission. *Aedes albopictus* breeds principally in plant containers throughout Indochina and is the

¹ Previous keys were for Korea (I), Formosa (II), Malaya (III), and Anglo-Egyptian Sudan (IV). See Mosquito News, vol. 13, nos. 1, 2, and 4, 1953. Keys to Malaya, the Sudan and French Indochina were drawn by Sally D. Kaicher.

MOSQUITOES OF MEDICAL IMPORTANCE - FRENCH INDO-CHINA

IMPORTANT
A SPEC MEN MUST HAVE
ALL CHARACTERS RECORDED
FOR THAT SPECIES

FULL-GROWN LARVAE



INSECT IDENT. DEPT. USDA
UNITED STATES DEPT. OF AGRICULTURE
SECRETARY OF AGRICULTURE
NOVEMBER 1932

MOSQUITOES OF MEDICAL IMPORTANCE - FRENCH INDO-CHINA

IMPORTANT
A SPECIES MUST HAVE
ALL CHARACTERISTICS
FOR THAT SPECIES

LONG PALPS ON
ANOPHELES

MALES HAVE BUSHY ANTENNAE (long or feathery) AND DO NOT BITE

NO LIGHT SPOT AT CROSS VEIN

LAST SEGMENT ENTIRELY LIGHT, OR LIGHT SEGMENT LONGER THAN INTERVENING DARK BAND

LIGHT SPOT AT CROSS VEIN

LIGHT SPOT AT CROSS VEIN

PATTERN ON PALP

PATTERN ON PALP

PATTERN ON PALP

PATTERN ON PALP

PATTERN ON PROBOSCIS

PATTERN ON PROBOSCIS

PATTERN ON PROBOSCIS

PATTERN ON PROBOSCIS

PATTERN ON HIND TARSUS

PATTERN ON HIND TARSUS

PATTERN ON HIND TARSUS

PATTERN ON HIND TARSUS

PATTERN ON THORAX

PATTERN ON THORAX

ALL WHITE

ALL WHITE

PATTERN ON HIND TARSUS

PATTERN ON HIND TARSUS

ADULT MOSQUITO WITH PARTS LABELED

INSECT IDENT. BRPD, USDA
UNIVERSITY OF CALIFORNIA
SECRETARY OF AGRICULTURE
NOVEMBER, 1952

ANOPHELES SINENSIS

ANOPHELES MINIMUS

ANOPHELES ACONITUS

ANOPHELES JAYAKOENIGSI

ANOPHELES SUNDANICUS

AEDES ALBOPICTUS

AEDES AEGYPTI

ANOPHELES MACULATUS

chief vector of dengue fever. *Aedes aegypti* breeds principally in artificial containers near human habitations. It is included in the key because of its role in

the transmission of dengue and its ability to transmit yellow fever, the introduction of which is a serious and constant threat to the entire Orient.

TESTS WITH GRANULATED BHC AND DIELDRIN FOR CONTROLLING SAND FLY LARVAE

G. C. LABRECQUE, U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine,
AND R. L. GOULDING, Co-Operative Sand Fly Research Unit^{1, 2}

The salt-marsh sand fly, *Culicoides furens* (Poey), breeds abundantly in the densely foliated tidal marshes bordering the Florida Intracoastal Waterway, and often causes severe annoyance to the inhabitants of the adjacent areas. Since preliminary tests with bentonite granules impregnated with an insecticide showed great promise against *furens* larvae, tests were conducted on a practical scale to evaluate the method further.

Recent studies have shown that applications of certain insecticides to marsh breeding areas provide effective control of sand fly larvae for several months (Goulding *et al.* 1953). Treatments may be made with ground equipment, but this is time-consuming and extremely costly where it is necessary to cut extensive access trails through dense mangrove. Treatments may also be applied as aerial sprays, but so much material is lost by impingement

on the vegetation, principally red and white mangrove, that excessive amounts must be applied to insure the proper amount reaching the ground. Since similar problems of penetrating vegetation for the control of mosquito larvae in rice fields and salt marshes had been overcome by applying granulated insecticides (Whitehead 1951, Keller *et al.* 1953), it was thought that this method might also be suitable in sand fly control.

On January 16, 1952, 325 acres of marshland infested with sand fly larvae north of Fort Lauderdale, Fla., were treated by airplane with bentonite granules (16/30 mesh) impregnated with BHC (36 percent gamma isomer). The average rate of application was 2 pounds of the gamma isomer per acre. Comparative treatments were made a month later with an oil spray containing sufficient BHC to give 0.5 pound of the gamma isomer per gallon, which was applied to a 24-acre plot at the rate of 4 gallons per acre. An 8-acre plot was treated with 5 percent of dieldrin on bentonite granules, at the rate of 1.25 pounds of dieldrin per acre. An isolated, untreated 80-acre plot was utilized as a check.

The granulated BHC was prepared in a cement mixer by spraying melted BHC on the bentonite while the mixer was in operation, adding 2.8 pounds (containing 1 pound of gamma isomer) to 9.7 pounds of bentonite. The granulated dieldrin was a commercial product.

¹ This unit is under the technical supervision of the Orlando, Fla., laboratory of the Bureau of Entomology and Plant Quarantine. It is supported by funds allotted to the Bureau by the Department of the Army; by the Anti-Mosquito Districts of Dade, Broward, and Palm Beach Counties and the Indian River Mosquito Control District; and by the Division of Entomology of the Florida State Board of Health.

² The writers acknowledge the advice and direction of W. V. King, W. C. McDuffie, and J. C. Keller in this work; the assistance of W. C. Byrum, F. W. Hardin, J. A. Parker, H. Edwards, and H. H. Taylor; and the cooperation of J. H. Bertholf, director of the Broward County Anti-Mosquito District.

The hopper of an airplane duster was adapted for use and was set to deliver 25 pounds of granulated insecticide per acre, the plane traveling at a speed of 100 miles per hour. From an altitude of 70 feet 50 percent of the granules fell within an area 27 feet wide, and this swath width was used in applying the granulated insecticides.

The larval population was estimated from soil samples taken at selected stations. In the preliminary survey of the 325-acre area 456 stations were sampled, and 87 that produced the most larvae were selected for subsequent samplings. Fifteen stations were used in the 24-acre plot, 12 in the 8-acre plot, and 27 in the 80-acre check. Beginning in October, each plot was sampled three times prior to treatment. The degree of control was based on differences in counts before and at various intervals after treatment. Large variations occurred in the untreated plot, but since it was not known whether they were representative of the treated plots, no adjustments to correspond with these changes were made by use of Abbott's formula.

The abundance of adult sand flies in the plot treated with granulated BHC was measured by means of two modified mosquito light traps and four animal traps located within or adjacent to it. One animal trap was placed in the check plot, but none were used in the other treated plots. The animal traps were baited with white rats.

The effect of the treatments on the larval populations is shown in table 1.

Excellent control was obtained with granulated BHC during the first 12 weeks, but at 16 weeks there was a sharp increase in larval populations throughout the plot, and at 20 weeks little or no control was indicated. With the BHC spray the initial reduction was only 77 percent, and after 4 weeks little or no reduction was evident. The better results obtained with the granulated BHC were attributed to better penetration of the foliage.

Control with granulated dieldrin ranged from 94 to 99 percent for 24 weeks, when observations were discontinued.

The numbers of adult sand flies taken in light and animal traps declined markedly immediately after treatment and remained at a low level for 2 months. During the third month there was an increase in the catches in the animal traps, and a very great increase in the light traps. Some measure of control was indicated during the fourth month, but by the fifth month populations were higher than before treatment. The treated and check plots both exhibited the same trends in adult abundance throughout the test, the only difference being that the numbers were much greater in the check plot.

SUMMARY.—Aerial sprays have not been effective against larvae of the salt-marsh sand fly, *Culicoides furens* (Poey), in the tidal marshes bordering the Florida Intracoastal Waterway, because they do not penetrate the dense mangrove and other

TABLE 1.—Effect of aerial applications of granulated BHC and dieldrin and of BHC spray on sand fly larvae.

Insecticide and form	Pounds of toxicant per acre	Pretreatment counts (average per sample)	Percent reduction after—						
			2 weeks	4 weeks	8 weeks	12 weeks	16 weeks	20 weeks	24 weeks
BHC (36% gamma):									
Granulated	2	10	97	87	93	91	65	14	..
Oil spray	2	9	77	33	22	+4	..	..	..
Dieldrin, granulated	1.25	20	94	99	95	99	96	..	99
Untreated (check)	..	7	16	+111	+121	30	+246	24	..

vegetation satisfactorily. In recent tests granulated insecticides have been found to give good control.

Granulated BHC applied at the rate of 2 pounds of gamma isomer per acre gave excellent control of the larvae for 12 weeks. A sharp increase in larval abundance occurred after 16 weeks, and little or no control was indicated at 20 weeks.

Granulated dieldrin applied at the rate of 1.25 pounds of dieldrin per acre gave excellent control for 24 weeks.

An aerial spray in which BHC was applied at the rate of 2 pounds of gamma

isomer per acre gave some control for 2 weeks but little or none thereafter.

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A GYNANDROMORPH OF *CULEX PIPPIENS MOLESTUS* (FORSK.)

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The gynandromorph described was found among a laboratory strain of *Culex pipiens molestus* maintained in the Department of Parasitology of the Hebrew University. The mosquito emerged on 29-IV-1951 and was among a group removed from the cage on 2-V-1951. Following discovery of the gynandromorph, all mosquitoes which had emerged on the previous day and for several days thereafter were examined without finding other aberrant forms. The specimen is pinned and the genitalia mounted on a slide. The left side of the specimen has male, the right female characteristics.

Description: Antennae: male, whorled hairs not quite so dense as in normal male, segmentation normal, female with hairs slightly longer than in normal female, segmentation normal. Palpi: distal hairs on male side slightly longer than on normal male, female palpus normal. Proboscis: almost intermediate but more closely resembling that of female. Female eye larger than male; anterior-posterior distance across the

vertex of the head greater on female side than on male. Thorax: dorsum with uniform scaling and chaetotaxy, pleurae with equal scaling and chaetotaxy on both sides; tarsi: left front tarsus with two equal sized toothed claws, right front tarsus as in normal female, left mid-tarsus with one large and other smaller toothed claw, right mid-tarsus as in normal female, hind tarsi as in normal male and female respectively; wings: male wing not quite 4mm in length, female wing 4.75mm, width of female wing greater, both wings normally scaled; abdomen: tergites dark brown with pale scales basally, tergites five to eight with the pale scales extending laterally almost to the apical edge of the tergite on the female side, pale scales not thus extended on the male side; genitalia: (see fig. 1) left side nearly as in normal male except that the basal plate is not present in normal form but probably represented by a large rod-like structure displaced below the base of the paraprot, right

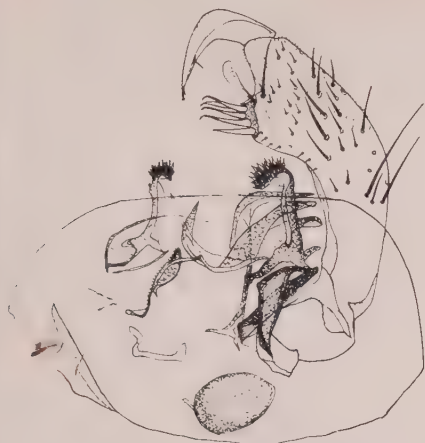


FIG. 1. *Culex pipiens molestus*. Genitalia of gynandromorph.

side with paraproct of nearly normal size present and in addition a rudimentary process at the inside of the paraproct which may represent the not fully developed ventral arm of the mesonome, the cercus on the female side is possibly represented by a small protuberance at the lower inner side of the paraproct; one spermatheca is present of the normal number of three.

Four gynandromorphs of *C. pipiens molestus* have previously been described, one by Marshall (1938, pp. 312-313), and three by Gilchrist and Haldane (1947). Roth (1948) reviewed the literature on gynandromorphs up to that date aggregat-

ing about twenty cases. Also in addition to the records reviewed by Roth, Weyer (1938) described a gynandromorph of *Culex pipiens* and Smyly (1942) one of *Aedes aegypti*; Bates (1949, pp. 65 and 79) refers to two gynandromorphs of *Haemagogus spegazzinii* and one of *Culex coronator* found in the course of his work in South America. Considering the enormous number of mosquitoes which have been examined, it appears that the occurrence of gynandromorphs and sex mosaics among the Culicidae is quite rare.

The specimen herein described has been deposited in the collection of the Department of Parasitology of the Hebrew University, Jerusalem.

The author gratefully acknowledges the aid and advice of Professor O. Theodor of the Department of Parasitology, Hebrew University, in the preparation of this paper.

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Authors of papers which were delivered at the joint meetings of the American Mosquito Control Association and the New Jersey Mosquito Extermination Association please note that according to official action taken by the two associations, the papers are to be published in the *Proceedings* of the New Jersey Mosquito Extermination Association, unless specific arrangements have been made to the contrary. Certain papers which had already been cleared through official channels for publication in *Mosquito News* will, of course, be printed in *Mosquito News*.

A NOTE ON THE CHAETOTAXY OF *Aedes vexans* (MEIGEN, 1830).¹

A. RALPH BARR

In identifying larvae of *A. vexans* from Minnesota the writer has noticed a great deal of variability in the branching of the upper and lower head hairs. The same seems to be true of the lateral abdominal hairs. These hairs were noticed particularly since they are used extensively as key characters for identification. When the results of the study were compared with those of workers in other areas, some interesting suggestions arose; these form the subject of this paper.

A series of 87 larvae of *A. vexans* were examined and the branches² of the upper and lower head hairs were counted; there were too few lateral abdominal hairs intact for adequate observation. The larvae all appeared to be in the fourth instar and they were mounted in Canada Balsam. The results are shown in the following table:

Hair	Number of Hairs of <i>A. vexans</i> Larvae with (No.) Branches								Total
	1	2	3	4	5	6	7	missing	
Upper head hair	0	7	30	84	37	5	1	10	174
Lower head hair	6	85	68	9	0	1	0	5	174

There was a total of 174 pairs of hairs for study, 87 pairs of upper head hairs and the same number of lower head hairs. Of these 174 pairs there was one hair of the pair missing in 15 cases so that actually only 159 pairs were available for study. Of these 159 pairs, the number of branches in each member of a pair was similar in 98 and was different in 61. This shows that the number of branches in one member of a pair (on one side of the

head) is largely independent of the number of branches in the other member of the pair (on the other side of the head). For this reason each hair was tabulated separately rather than by pairs.

Thus, there was a range of two to seven branches in the upper head hairs with an average of 4.0; the most frequent numbers of branches were three, four, and five. There was a range of one to six branches in the lower head hair with an average of 2.5; the most frequent numbers of branches were two and three.

In examining these specimens it was noticed that many hairs had a number of tiny "branches." As a rule these tiny "branches" were more numerous on hairs with fewer branches, (one- or two-branched hairs); for example, a one-branched lower head hair had about nine

or ten of these filaments all along the hair.

Most workers examining this species have mentioned little or no variation in these hairs but some workers have. McLintock, working in Canada, found considerable percentages of larvae with the upper head hairs four- to five-branched and the lower head hairs three-branched; and Natvig, studying Danish and Fennoscandian specimens, found the upper head hairs four- and five-branched and the lower ones three-branched.

In contrast to these studies on northern populations of *A. vexans*, most workers in the United States have found the upper head hairs three-branched and the lower

¹ Paper No. 2994, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul 1, Minn.

² The use of the word "branch" is conventional; single hairs are 1-branched, double ones 2-branched, etc.

ones two-branched, and Marshall in England found the upper head hairs to be two- to four-branched and the lower ones one- to three-branched in fourth instar larvae.

In the Asiatic form, *A. v. nipponii* (Theob.), which replaces typical *A. vexans* in the Oriental region south of the Palearctic region, Lacasse and Yamaguti found the upper head hairs to be two- to five-branched and the lower head hairs to be one- to two-branched; their mosquitoes were from Japan and Korea. Bohart and Ingram, in specimens from Okinawa, report the upper head hairs to be two- to four-branched (usually three-branched) and the lower ones to be one- to two-branched (usually two-branched). These authors also report the upper head hairs of the Australian form to be one- to three-branched and the lower head hairs to be single. They resurrected the name *nocturnus* (*A. v. nocturnus* (Theob.)) for this form since it differed from the Oriental form in lacking the extensive white markings of the abdomen and also differed from the typical form in having the lower head hair single.

These results suggest the existence of a cline in the amount of branching of these two pairs of hairs, the upper head hairs of the northern forms from Canada and northern Europe being predominantly four- or five-branched and the lower head hairs being predominantly two- or three-branched, while in such intermediate areas as the United States and the south of England the upper head hairs are predominantly three- or four-

branched and the lower ones two-branched. Minnesota specimens are intermediate between these two types.

In more southerly areas such as the Oriental and Australasian regions the upper head hairs seem to be predominantly three- or four-branched or even two- or three-branched and the lower head hairs one- and two-branched. Since the Australasian form may represent merely the extreme of a cline, the wisdom of recognizing it nomenclatorially may be doubted.

A great deal of work is needed before any generalization can be made but it is entirely possible that the amount of branching of a hair may not be rigidly determined genetically. Environmental factors such as temperature may alter the expression of such a genetic trait. This would seem to have an important bearing on the theory of chaetotaxy of mosquito larvae.

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At the recent meetings of the American Mosquito Control Association at Atlantic City it was voted to hold the meetings for 1955 jointly with the California Mosquito Control Association in Los Angeles, January 24-27, 1955.

THE PRESENT STATUS OF THE *CULEX TARSALIS* COLONY AT THE ROCKY MOUNTAIN LABORATORY¹

JAMES M. BRENNAN, WILLIAM A. RUSH, AND ALEXANDER A. HUBERT

The successful colonization of *Culex tarsalis* by Brennan and Harwood (1953) was published as a preliminary report. Since then, our techniques for maintaining the colony and subcolonies have been somewhat modified and will be reported along with additional notes and observations in a subsequent paper.

The interest expressed in, and the demands made on, the Rocky Mountain Laboratory colony have been greater than anticipated. In addition to our own use of the colony in virus research and related programs, which require prodigious numbers of adult females, we have supplied eggs and/or gravid females to several other laboratories.

A brief note on the current status of the colony is given here to benefit those who may require initial or additional material in their varied research programs, and to encourage the more extensive utilization of *Culex tarsalis* as a new and useful laboratory tool.

The colony, established in the late summer of 1952, is flourishing and at this writing is in its estimated twentieth generation. Both larvae and adults continue to be large, hardy, and vigorous. There has been no suggestion of a diapause. Any physiologic or genetic changes which may have occurred through inbreeding have

certainly not affected the well-being of the colony. There has been no interference with or apparent influence on the efficiency of the mosquito as a vector of the virus of western equine encephalitis or as a host for the avian malarial parasite, *Plasmodium relictum*.

Following exposure of a number of generations to the conditioning process described by Brennan and Harwood (*op. cit.*) it has been found that breeding can be continued satisfactorily in small cages in the absence of controlled light, with consideration only for humidity and temperature, and that animals other than chickens are suitable sources of blood meals for maintenance of a colony.

Because of present demands our insectary routine is now geared to a daily minimal egg production of 20 rafts from the main stock colony. Physical facilities are such that this figure may be increased greatly should the need arise.

Elementary as it may seem, still, in view of two unfortunate experiences which we have encountered elsewhere, we have been prompted to inspect our colony frequently and to take samples for precise identification as a safeguard against possible contamination by other mosquito species, thus insuring a pure culture of *Culex tarsalis*.

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SUGGESTED IMPROVEMENTS FOR AN UNBREAKABLE ASPIRATOR AND KILLING TUBE¹

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For many years, glass tubes have been used in the construction of aspirators for collecting adult mosquitoes and other insects; consequently, there has always been the hazard of breakage. A thin gauze barrier has usually been used to prevent the insect from being sucked up into the mouth.

Aspirators are made in various forms; often the insects, as they are caught, are retained temporarily in a glass cylinder or test tube, and are later transferred to a glass killing tube or jar.

Some entomologists, in an attempt to avoid the hazards of glass, use plastic tubes for their aspirators. The author, having been one of those who have lost valuable specimens through breaking of glass containers, has designed an unbreakable aspirator which may be made with rigid or flexible plastic tubing.

The chief feature of this aspirator is an adapter made from 5/8-inch hardened aluminum rod stock and having a total length of 1 1/4 inches. (Fig. 1). It should be machined on a lathe, but requires very little work in its construction. The anterior half inch of the rod is cut to a diameter of 1/2-inch, and is intended to receive the plastic tube. The next 3/16-inch is left untouched, but may be knurled, if desired. The last 9/16-inch is cut to a diameter of 5/16-inch, and is intended to receive the rubber hose. A 1/4-inch hole is then bored through the entire adapter while it is mounted horizontally on the lathe.

Instead of gauze, the author uses #28

gauge brass screening, but any gauge between #18 and #28 may be used. Since the individual wires in #28 gauge screening are very close together, cementing of the screening to the adapter is made easier. A round piece having a diameter of 7/16-inch is cut from the screening, and is cemented to the front end of the adapter with a powerful rubber cement-type adhesive known as "Pliobond," manufactured by the Goodyear Tire and Rubber Company.

A convenient length for the rubber tubing is 25 inches. An excellent type is red rubber cloth-impression tubing having a 3/16-inch bore and a 3/64-inch wall thickness. A mouthpiece 2 inches long is cut from rigid plastic tubing of 3/16-inch diameter, but a pipe stem may be used, if desired. Both ends of the plastic mouthpiece may be flared, simply by holding in a flame for a few seconds.

The collecting tube itself may be made either of flexible or rigid transparent plastic tubing having a bore of 1/2-inch and a wall thickness of 1/16-inch, the outside diameter being 5/8-inch. If flexible tubing is used, the adapter will also fit a tube of 3/32-inch wall thickness and 15/32-inch bore. An excellent type of flexible tubing is that known as "Tygon," manufactured by U. S. Stoneware, Akron 9, Ohio. A convenient length is 14 inches. The "Tygon" tubing will retain a slight bow or curvature after being doubled up on itself, and may be bent to any desired arc without damage or apparent wear to the material. It may be folded and placed in the pocket. There are several degrees of flexibility, but the less flexible type seems to be best for use as an aspirator. The tube fits over the forward end of the adapter, and grips the latter firmly. A cork may be inserted in the front end of

¹ The material presented herein does not necessarily constitute an indorsement by the Department of Defense.

² Now Lt. Commander, U. S. Public Health Service, FOA Mission to Liberia, % American Embassy, Monrovia, Liberia, West Africa.

the tube to retain insects until they are transferred to the killing tube. Figure 2 shows the assembled aspirator.

If rigid plastic tubing is used, it will stand up very well, but the ends must be protected, as fracturing may occur when rigid plastic tubing falls on end. A $\frac{1}{2}$ -inch piece of rubber or flexible plastic tubing fitted over each end will prevent fracturing of the rigid plastic; the bore of this protective piece should equal $\frac{5}{8}$ -inch, so as to fit snugly over the collecting tube.

Rigid plastic tubing may be bent if heated gently and evenly on a hot metal plate, over a flame, in a dry sterilizer, incubator, or oven, or by placing the plastic in boiling water for 3 to 5 minutes. It is wise to experiment with small pieces first, in order to ascertain the bending properties of the plastic. Plastic tubing may be drawn out like glass when carefully heated in a Bunsen flame, thereby avoiding use of an adapter; however, a gauze barrier is necessary in this case. Rigid tubing is best cut with a saw having a hacksaw-type of blade. Unlike glass, plastic tubing cannot be broken by scratching it transversely with a file. Rigid plastic tubing may be obtained from the Plax Corporation, Hartford, Connecticut, from the American Phenolic Corporation, Chicago, Illinois, or from any retailer of plastics.

Plastic tubes may also be used for other purposes in insect survey activities. A 15 cc rubber bulb on a 10-inch piece of $\frac{1}{4}$ -inch plastic tubing yields an oversized, unbreakable pipette for rapidly collecting mosquito eggs, larvae, and pupae.

The usual killing tube consists of a glass tube at the bottom of which is a deep layer of sodium or hydrogen cyanide or rubber fragments soaked in chloroform. The killing agent is covered with several layers of porous material, and tight-fitting discs of blotting paper keep all the other layers in place.

The author has found it convenient to use a transparent celluloid test tube and a single plug made from a cellulose

sponge. The test tube is made of Lusteroid, and is sold by several scientific supply companies. A convenient size is 6 inches long and $1\frac{1}{4}$ inches in diameter.

A plug, the diameter of the test tube, is cut from a size 2C "O-Cel-O" cellulose sponge. It is pushed down into the tube, and will remain in place indefinitely if it fits snugly. (Fig. 3). Eight such plugs can be cut from one size 2C sponge. A yellow color is suggested, as it provides a suitable background for viewing insects.

Neither carbon tetrachloride nor cyanide has any effect on the Lusteroid test tube or the artificial sponge. Liquid chloroform affects the tube slowly during prolonged contact, but if chloroform is used sparingly, a tube will last a long time. The synthetic sponge is not affected in any way by chloroform. Ether should not be used in a Lusteroid tube, since it softens the tube rapidly.

A chloroform killing tube may be assembled in several ways. If a sponge plug is pushed to the bottom of an unbreakable tube, and 1 cc of chloroform is slowly spread over the sponge, it will retain the chloroform for many days. There will be initial sweating of the walls of the tube due to the heavy fumes, but after the tube has been in use for a short time, the sweating ceases.

A simple variation of the usual chloroform tube may also be employed. Small pieces of rubber, which have been soaked in chloroform for several hours, may be placed in the bottom of the tube to a depth of about $\frac{3}{4}$ -inch. A synthetic sponge plug is then pushed down the tube and against the rubber fragments. As the chloroform evaporates slowly from the rubber, the fumes penetrate the sponge and are retained for many weeks. Passage of the fumes through the cork may be prevented by dipping the cork in hot paraffin.

A plug of synthetic sponge may be soaked in carbon tetrachloride for several hours. The liquid is then squeezed out, and the plug is pushed to the bottom of a Lusteroid tube. If desired, a dry plug

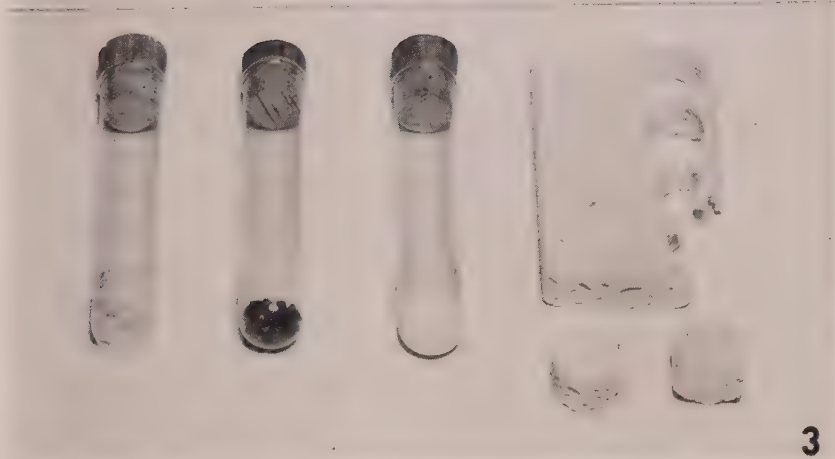
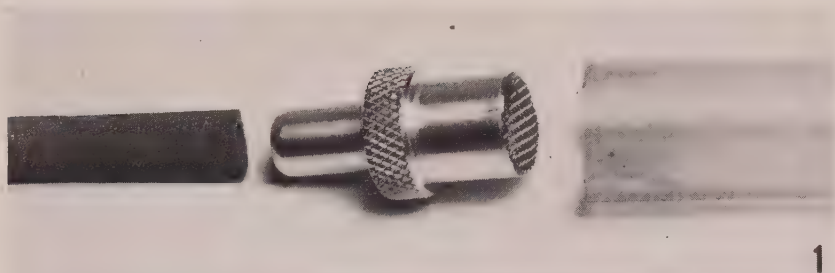


FIG. 1. Close-up view of adapter.

FIG. 2. Complete aspirator. The transparent portion is "Tygon" plastic flexible tubing.

FIG. 3. Plastic killing tubes made in various ways, i.e., with artificial sponge plug alone, and with sponge plug holding chloroform-soaked rubber and potassium cyanide in place.

is inserted initially, and is then covered with carbon tetrachloride. After several hours, the chemical is poured off and the tube is left uncorked until most of the liquid has evaporated. The sponge will retain the fumes for a considerable time.

A cyanide tube may be easily made by placing a one-inch layer of potassium cyanide at the bottom of a Lusteroid tube, and covering it with a tight-fitting synthetic sponge plug. No other layer is

necessary, but it is to be emphasized that the plug must fit very tightly over the poison.

In ordinary use, a killing tube is not exposed to a flame, but it should be remembered that Lusteroid is a type of celluloid and will burn if brought into direct contact with a flame. There are several types of plastic test tubes and vials available which may be used in place of Lusteroid, if desired.

THE MOSQUITOES OF NEW MEXICO¹

F. F. FERGUSON, Scientist (R.) AND T. E. McNEEL, SR., Sanitarian (R.)

Lower Mississippi and Western Gulf Drainage Basins Office,
Little Rock, Arkansas

The mosquito fauna of New Mexico first received attention due to malaria which was present in the irrigated valleys of the State. This disease was a major problem in the 1920's, but incidence has declined during the past decade in line with the national trend (1, 2, and 3). With the expansion of irrigation agriculture in recent years, mosquito-borne encephalitis has become more prominent as a problem. Most of the mosquito species recorded from New Mexico have been disease-vectors or pests of man and animals.

This note summarizes the data known from early and recent works on the mosquitoes of the State.² The most recent collection data are from the northeast quadrant of the State and were taken mainly from a series of nine New Jersey type mosquito light traps run during 1951

and/or 1952. Traps were operated in the range of 44 to 73 trap nights per season for a total of 559 trap nights for the period of study. Trap stations were confined to reservoirs or irrigation districts. The mosquito seasons studied extended from approximately June 1 through the month of October.

Over half of the mosquitoes taken were *Culex tarsalis*, noted for encephalitis vocation. This species may be collected during the entire mosquito season. Other very common species found were *Aedes dorsalis*, *Aedes nigromaculis* and *Culiseta inornata*. The latter species has the unusual habit of breeding in all months of the mosquito season in this area.

SPECIES RECORDED

Anopheles freeborni, *A. crucians*, *A. punctipennis*, *A. pseudopunctipennis*, and *A. franciscanus*.

Aedes aegypti, *A. atropalpus*, *A. campestris* (?),³ *A. canadensis*, *A. dorsalis*, *A. increpitus*, *A. mitchellae*, *A. nigromaculis*, *A. sollicitans*, *A. trivittatus*, and *A. vexans*.

¹ From the Communicable Disease Center, Public Health Service, U. S. Department of Health, Education, and Welfare, Atlanta, Georgia.

² This survey of the mosquito fauna of New Mexico is a function of the Mosquito Control and Allied Problems Work Group of the Arkansas-White-Red River Basins Inter-Agency Committee which is planning water resources developments in the general region.

³ Barber's question (1).

Culex apicalis, *C. quinquefasciatus*, *C. restuans*, *C. salinarius*, and *C. tarsalis*.

Culiseta incidens and *C. inornata*.

Orthopodomyia signifera.

Psorophora confinnis, *P. cyanescens*, *P. discolor*, and *P. signipennis*.

Uranotaenia sapphirina and *U. syntheta*.

Records for *Aedes canadensis*, *A. in-crepitus*, *A. nigromaculis*, *A. mitchellae*, *A. trivittatus*, *Culex restuans*, *Orthopodomyia signifera*, *Psorophora confinnis*, *P. cyanescens*, (4) *P. discolor*, and *Uranotaenia sapphirina* are new additions to the State list.

SUMMARY

This preliminary report summarizes the native mosquito fauna of New Mexico for the first time and lists *Culex*

tarsalis, *Culiseta inornata*, *Aedes dorsalis*, and *Aedes nigromaculis* as the most common forms studied during two recent seasons of trapping in northeast New Mexico.

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CORRECTED DISTRIBUTION RECORDS OF *CULEX* *STIGMATOSOMA* IN TEXAS

G. C. MENZIES AND R. B. EADS

Bureau of Laboratories, Texas State Department of Health, Austin

Information relative to mosquito species distribution in West Texas obtained by the operation of approximately 50 New Jersey light traps in 1945 and 1946 has been reported by Eads, Menzies and Ogden (1951). This work erred in that *Culex thriambus* Dyar, 1921, was considered to be a synonym of *Culex stigmatosoma* Dyar, 1907. The latter species was listed as having been taken from Brewster, Coleman, Edwards, Jim Wells, Kerr, Kimble, Mason, McCulloch, Pecos, Reeves, Runnels, Shackelford, Sutton, Tom Green, Uvalde, and Wheeler Counties in Texas.

Recent review of the slides of male terminalia on which these records were based has revealed that, with two exceptions, the species involved was actually *Culex thriambus*. These two mosquitoes

are somewhat similar with respect to gross adult morphology, although the male terminalia are readily distinguishable, and the larvae are radically different.

This paper summarized the records of these two species of mosquitoes in the collection of the Texas State Department of Health. Some data are included which were not available at the time of the publication by Eads, et al. (1951). All speciation has followed a study of male terminalia.

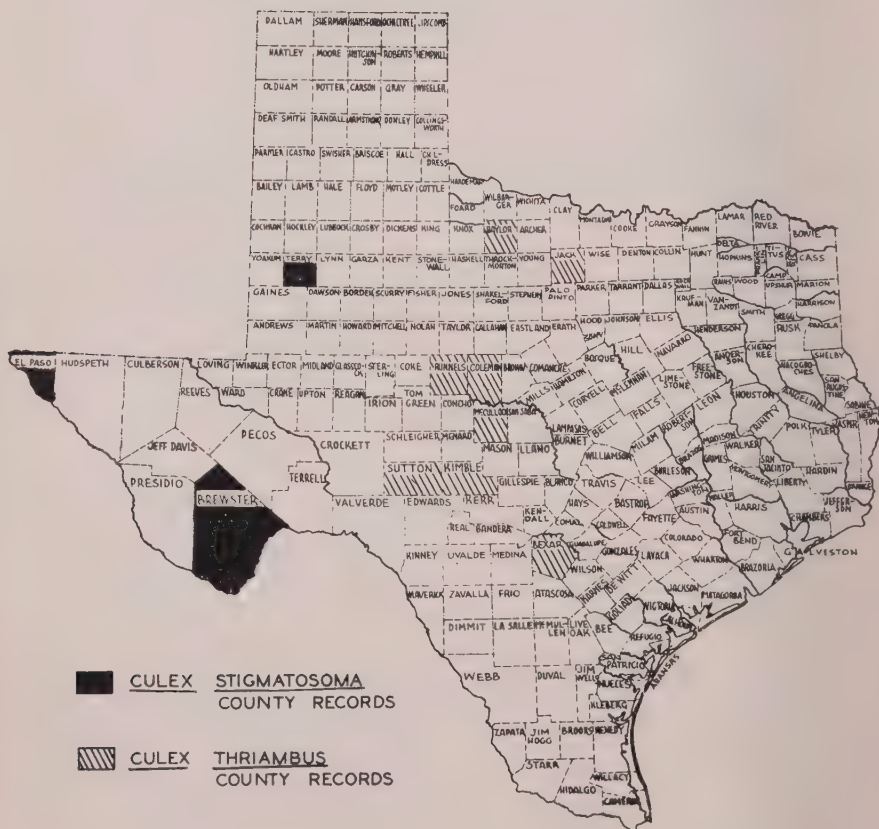
Culex stigmatosoma. 30 males, September 26, 1944, El Paso County, Collectors D. R. Lindsay and L. J. Ogden; 4 males, September 26, 1944, Brewster County, Collectors D. R. Lindsay and L. J. Ogden; 1 male, October 2, 1944, Terry County, Collectors D. R. Lindsay and L. J. Ogden.

Culex thriambus. 3 males, July 1, 1945—4 males, July 2, 1945—1 male, July 5, 1945—1 male, July 7, 1945, Kimble County, Collector T. M. Simmons; 2 males, July 2, 1945, Sutton County, Collector L. Spraggins; 1 male, July 5, 1946, Jack County, Collector R. H. Tate; 1 male, September 25, 1945, Baylor County, Collector, B. R. Nix; 1 male, July 28, 1946, Runnels County, Collector A. D. Smith; 1 male, July 2, 1945, McCulloch County, Collector, E. H. Nixon; 1 male, May 14, 1946—1 male, June 3, 1946—2 males, June 30, 1946—1 male, July 28, 1946, Coleman County, Collector, C. H. Shore; 1 male, September 19, 1953, Camp Bullis (Bexar County), Collector, J. S. Wiseman.

As can be seen from the accompanying plate, according to Texas State Health Department records, *Culex stigmatosoma* is restricted in its Texas distribution to the extreme western tip of the state. If the number of specimens in our collection from El Paso County may be used as a criterion, the species is abundant in this county. *Culex thriambus*, originally described from Kerville (Kerr County), Texas, is prevalent over a wide area in central and west Texas.

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FADS, R. B., G. C. MENZIES, AND L. J. OGDEN. 1951. Distribution Records of West Texas Mosquitoes. Mosq. News, 11(1):41-47.



NOTES ON THE BIOLOGY OF *CULISETA MELANURA*
(COQUILLET)E7
✓

ROBERT C. WALLIS *

Studies of the ecology and bionomics of mosquitoes have been limited chiefly to species which feed on man to the extent that they are either extremely pestiferous or are important as disease vectors. However, as epidemiological studies point out the importance of mosquitoes as vectors of arthropod-borne diseases, knowledge of the not so well-known species is becoming more and more important. There is little information available concerning *Culiseta melanura*, and the purpose of this article is to report observations on the biology of this species.

The small, dark *Culiseta melanura* are very similar in gross appearance to *Culex pipiens*. Matheson (1944) stated that they are rare and local except in some southern localities. They are known to breed in permanent fresh-water swamps and marshes. They occur in the eastern United States from the Gulf coast to Canada. Among northern Atlantic coast states this species has been reported from Maryland (Bishopp, Cory and Stone, 1933); Delaware (MacCreary and Stearns, 1935); New Jersey (Headlee, 1945), (Smith, 1904); New York (Felt, 1904), (Dyar, 1928); Rhode Island (Knutson, 1943); Massachusetts (Tullock, 1939); and New Hampshire (Lowry, 1929). The author has found no report of this species from Connecticut up to the present time.

While collecting mosquitoes in a small cave near Shade Swamp, Bristol, Connecticut, November 3, 1953, an adult female *C. melanura* was caught and transported to the laboratory. The specimen was placed in a warm (room temperature—mean 76° F. $\pm$ 5 degrees) moist lantern cage provided with a small water container for oviposition. Sucrose solution for food was provided daily. On November 25 a small, dark *Culex*-like egg raft

was observed on the oviposition site. This was removed and placed on the water surface in a larval-rearing pan, and within two days about a hundred larvae had emerged. These were allowed to develop under routine rearing conditions in white enameled pans containing about one inch of tap water and a few laboratory Purina rabbit feed pellets. While the larvae exhibited very little activity, growth was rapid and the first pupae developed on December 4. As they developed, pupae were transferred to water in the cage. All pupation was complete by December 11. Within three days of pupation adults began to emerge, and a total of eighty-three were collected. These were transferred to a one cubic-foot cage in which humid conditions were maintained. Blood meals were offered daily, both by extending the bared forearm into the cage and by placing a chicken in the cage for fifteen minute periods. This procedure was continued as long as adult mosquitoes remained alive. However, none of the females took blood, and no indication of mating or swarming activity was observed. Adult mortality continued daily, and by January 1 none of the original laboratory reared generation remained alive.

In commenting on the biology of *C. melanura*, Matheson (1944) said there was nothing known of its habits. He indicated that this species breeds in permanent water in swamps, and that the larvae overwinter under the ice in these places. Carpenter (1946) also said that this is believed to be the means of overwintering for *C. melanura* in the northern parts of the range. Smith (1904) reported that when larvae were collected in the field under winter conditions they failed to develop in the warm laboratory. He concluded that there was a period of suspended development during the larval stage in winter months, with exceptionally

*The Connecticut Agricultural Experiment Station, New Haven, Conn.

slow growth in the spring and a long delay before pupation. Felt (1904) wrote that the thin black-shelled eggs are laid singly on the surface of the water, and that breeding is probably continuous, with the adult hibernating.

While it is possible that the mosquito overwinters both in the larval stage and as hibernating adults, the author's observations indicate that as far north as Connecticut there are females prepared to lay eggs as late in the fall as December. When eggs from such females were collected and kept in the laboratory, they developed at a rate comparable to that of laboratory-reared *Culex*, and if sufficient food and warmth were provided in the aquatic medium there was no subsequent delay in development during the larval growing period as reported by Smith (1904). This suggested that either his larval-rearing techniques did not provide sufficient temperature or nutrient requirements, or that larvae could be conditioned by a cold winter aquatic environment so that development was delayed even when larvae were brought into room temperature laboratory conditions.

Because the lack of activity observed in the cage resembled that of strongly eurygamous species of mosquitoes, it is probable that this form will not be easily adaptable to colonization under laboratory conditions. Also, under the laboratory conditions employed here, *C. melanura* could not be induced to feed on either

man or chickens; therefore, further experiments will be necessary in order to determine the host which it prefers as a source of blood.

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ILLINOIS MOSQUITO CONTROL ASSOCIATION

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NEWS AND NOTES

THE SEVENTH ANNUAL MEETING OF THE VIRGINIA MOSQUITO CONTROL ASSOCIATION was held January 6, 1954 at the Williamsburg Lodge, Williamsburg, Virginia. About 125 persons attended and considerable interest was shown by many of them in several papers. In his report, President Dorer stated that there are now thirteen mosquito control districts in Virginia, protecting about one fifth of the state's population. Approximately \$350,000 is spent annually on mosquito control by the State of Virginia. A pertinent and often overlooked point in large scale mosquito control was brought out by Mr. Edwin Lazarus of the Tactical Air Command, U. S. Air Force, who emphasized that good surveys for larvae are a prerequisite of good results by airplane spraying.

Mr. V. D. McManus was elected President for 1954-55 and other officers were as follows: Mr. J. W. Dennis, Jr., 1st Vice-President, Mr. T. B. Noland, 2nd Vice-President, Mr. N. S. Beaton, 3rd Vice-President, Mr. Rowland E. Dorer, Secretary-Treasurer.

THE CALIFORNIA MOSQUITO CONTROL ASSOCIATION held its annual conference at the University of California in Berkeley on December 2 and at the Claremont Hotel in Oakland on December 3 and 4. According to Harold Gray, of the Alameda County Mosquito Abatement District, the meetings were well attended and unusually informative. Mr. Gray also notes that December was unseasonably warm and dry, necessitating an almost summer schedule for his district, but that since the salt marshes were nearly dry there were almost no *Aedes* larvae. He also recorded the finding of *Aedes varipalpus*, four months early, on December 18.

NEW PINK BOLLWORM RESEARCH CENTER DEDICATED. The new Pink Bollworm Research Center at Brownsville, Texas, was dedicated January 24, 1954, at an impressive ceremony participated in by Governor Allan Shivers of Texas; Congressman Lloyd Bentsen, Jr., of Texas; Ing. Mauro Ruiz Ayala, representing the Minister of Agriculture of the Republic of Mexico; Dr. R. D. Lewis, Director, Texas Agricultural Experiment Station; Hon. Harold Hutton, Commissioner of Agriculture of Oklahoma; Mr. G. G. Gibson, Director, Texas Agricultural Extension Service; Mr. Paul Mayfield, President, National Agricultural Chemicals Association; Dr. Clay Lyle, Director, Mississippi Agricultural Experiment Station; Dr. H. G. Johnston, National Cotton Council of America; and Dr. S. B. Pracker, Assistant to the Administrator, Agricultural Research Service, U. S. Department of Agriculture. Dr. Fred C. Bishopp, Coordinator, Pink Bollworm Research Center, welcomed the guests and introduced the speakers.

Dr. Bishopp, former Assistant Chief of the

Bureau of Entomology and Plant Quarantine, with the U. S. Department of Agriculture in Washington, left the Bureau on June 30 to assume the responsibility of coordinating the extensive research program to be carried on from the Pink Bollworm Research Center. This program involves work designed to meet the threat to the entire cotton industry of the United States through the recent rapid spread in this country of the world's most destructive cotton pest.

Although the main research efforts of the Center will be devoted to a solution of the pink bollworm problem, no doubt much of the basic information to be developed there will be broadly applicable to other insect problems including those involving mosquitoes.

The facilities at the Pink Bollworm Research Center include a 26-room air conditioned office and laboratory building; a building housing 5 bio-climatic cabinets; an insecticide building for gross experimental work with insecticides; a greenhouse with headhouse; a half-acre screened cage; and a building to house a shop, and to store automobiles and equipment. A few acres of land are available immediately adjacent to the laboratories on which cage and small plot experiments can be conducted. Irrigation water for this area and the large cage is provided from wells.

A unique feature of the setup is the provision of bio-climatic cabinets for duplicating temperatures and humidities of any area from which hydrothermograph records are available. These cabinets will make it possible to determine whether an insect would thrive in a given area in advance of the actual establishment of the pest in that area.

THE TENTH EDITION OF *Entoma* was issued by the Entomological Society of America in February. This widely-known and useful compendium of information on insecticides, fungicides, diluents, emulsifiers, adjuvants, equipment, trade names, manufacturers' addresses, research organizations and a multitude of other things of interest to workers in insect control, is obtainable from George S. Langford, University of Maryland, College Park, Maryland. The paperbound edition is \$2.00 and there are a few copies available in cloth binding, at \$3.00.

THE REPORT OF THE CENTRAL CO-OPERATIVE ANTI-MALARIA SOCIETY, LTD. for 1952 has been received from Calcutta, India, by this Association. The Indian society completed its thirty-third year in 1952, and at that time had 355 general members, 51 "ordinary members" and 5 life members. One hundred five of the general membership is presently in East Bengal, a part of Pakistan. Since the primary societies have been reduced from their former Government support, the Society appeals for contributions, stating that,

however small, they will be gratefully acknowledged and put to use in combating malaria, which they feel has been the principal cause of the ruin of Bengal, formerly a rich and productive state. The officers of the central Society, Messrs. Mukherjee and Chatterjee, state that the primary societies, wherever they have been able to establish them, have been successful in many villages in eradicating malaria. Unfortunately, even after thirty-three years of very strenuous effort, the central Society has been unable to establish and guide more than a very few of these local groups.

THE NAME OF THE JULIUS HYMAN & COMPANY Division of the Shell Chemical Corporation has been changed to the Agricultural Chemicals Division.

IN COLOMBIA, the Government has announced that eleven months after operations were commenced, protection against malaria has been afforded 1,225,000 persons by a project undertaken jointly by the Colombian Government, UNICEF and WHO. In this effort, the Government is meeting 80 per cent of the total cost of the project, UNICEF is providing supplies and equipment and WHO is providing specialized personnel, as it will continue to do through 1954. It has been estimated that 700,000 people suffer from malaria annually in Colombia, the malarious regions extending from sea level to an altitude of 1,700 meters and being inhabited by a population of about 6,800,000. Vast and naturally rich areas have been depopulated by malaria in Colombia, but it was not until the present internationally-sponsored effort that effective remedial steps have been possible. In the same project, spraying aimed at eliminating *Aedes aegypti* is also being conducted.

COLLECTION OF MOSQUITOES FROM WOOD RATS' NESTS was reported by Raymond Ryckman and Ken Arakawa in articles printed in the *Pan-Pacific Entomologist*, copies of which have come belatedly to hand. Species collected hibernating in the rats' nests included *Anopheles freeborni*, *Culiseta inornata* and *Culex tarsalis*. The authors found that mosquitoes apparently seek not only shelter from winter cold in the nest of the wood rat, *Neotoma fuscipes*, but apparently also seek shelter from the dry, hot environment as well.

THE FORTIETH ANNUAL REPORT OF THE UNION COUNTY (N. J.) MOSQUITO EXTERMINATION COMMISSION, covering the period from 1912 through 1952, has been received for review and contains photographs of control equipment and methods over the years which should be of much interest to everyone engaged in mosquito control. A foreword discusses the gradual progression of ecological change which has accompanied the control efforts.

C. Y. CHOW WRITES IN A LETTER TO TED RALEY, that the back numbers of *Mosquito News*

which Ted sent are very welcome and valuable additions to the library of the Insect-borne Diseases Control Training Center at Kurunegala, Ceylon. Dr. Chow returned to Ceylon in December after a two-month home leave in Formosa, during which he also visited India, Japan, Hong-Kong, Singapore and Thailand. In the latter country, he recounts, many members of the AMCA were in attendance at the WHO-sponsored First Asian Malaria Conference in Bangkok, including P. F. Russel, Jaswant Singh, Francisco Dy, Don Pletsch, M. E. Griffith, A. D. Hess and others.

JULIAN DE ZULUETA, WHO MALARIA ADVISOR ON THE SARAWAK MALARIA PILOT PROJECT, writes Ted Raley that he made a general survey of Sarawak in 1952 and that during 1953 he has been in charge of the malaria control pilot project there. The Project is supported jointly by the Sarawak Government and the World Health Organization and Dr. Zulueta feels that already progress can be noted in the effectiveness of their control efforts. Prior to going to Sarawak, Dr. Zulueta was in charge of malaria control in eastern Colombia.

HARRY H. STAGE ATTENDED THE EIGHTH PACIFIC SCIENCE CONGRESS, which was held November 16 through 28, 1953, in Manila, and reports that some 250 delegates and visitors attended the various meetings. Harry, who was then en route to his new post as Malaria Control Specialist for F. O. A. at Saigon, Viet Nam, was one of the panel of a two-day symposium on aspects of malaria. The symposium was moderated by Dr. MacKerras, of Australia, with A. D. Hess, of Manila, acting as recorder. Other panel members were: Josephine MacKerras of the Australian National Research Council, F. E. Baisas, of the Philippine Department of Health, T. L. Chang of WHO in Manila, Melvin Griffith of STEM in Bangkok, Stephen Hu of the Honolulu Board of Health, Luang Ayurakit Kosol of the Ministry of Health in Bangkok, Cornelius Kruze of Johns Hopkins, Emil Massal of the South Pacific Commission in New Caledonia, Jose B. Mendoza of the Department of Health in Quezon City, Manila, Cornelio Urbino of the Tala Malaria Laboratory of the Philippine Department of Health and Gaudencio Villanueva, Director of the Department of Health of the Philippines.

Several trips were included in the Congress activities, such as a visit to Corregidor and Bataan, the latter one of the most highly malarious localities still existing close to Manila, and to Rural Health Demonstration Centers in Quezon City and Angat, Bulacan Province. At the latter, three bus loads of delegates were met by the school band and paraded through an arch of welcome between throngs of flag-waving children, a colorful tradition in the Philippines. After the visit of inspection there were speeches and re-

freshments and the delegates then reviewed the school cadets.

Panel discussions were also held on filariasis, virus encephalitis, rural sanitation and training.

HARRY STAGE ALSO REPORTS, FROM SAIGON, that the job appears to be a big one but that fortunately he does not need to feel that he is starting from scratch inasmuch as Harry Pratt, Earle Lyman, Walter C. Baker and others of the USPHS have laid a fine groundwork in the early training of the local workers. The spraying teams have learned their lessons well, and are doing an excellent job, he adds; they will use some hundred tons of 50 per cent wettable DDT per year and are including Dieldrin in their plans as well. (Parenthetically, he says that their equipment "is that advertised regularly in Mosquito News—how else would I know what is available?")

"The other day," Harry continues, "I rode all day long on a slow train over beautiful hills of virgin teak, bamboo, palms, rubber and coffee and then, as we dropped down into the lowlands—endless rice paddies. Deer, wild boar, tigers and elephants roam these hills and wild peacock are considered good game, as well as the domestic chicken's ancestors.

"From this background of environment imagine the dozens of species of mosquitoes on each of about six contour levels, i.e., from sea level to altitudes of 3,000 feet. It's fortunate for us that the French entomologists and malarialogists of the Pasteur Institute have accumulated so much important information upon which we can develop and build an effective program."

GEORGE BURTON WRITES FROM THE FOA MISSION TO LIBERIA that he is finding evidence of the effectiveness of a buffer zone against immigrating adult mosquitoes. His teams are using dieldrin and are pushing ahead with a program of spraying all the areas surrounding the major breeding sites around Monrovia. Although only

about half of the areas of this demonstration project have been covered so far, mosquitoes are almost completely absent from sprayed but unscreened houses. Even unsprayed houses lying within this sprayed zone are nearly always free of mosquitoes, which seems to show that mosquitoes from outside the zone are killed by the sprayed houses before they can penetrate to the unsprayed ones. About an hour is apparently required for the dieldrin to be effective, and it seems to have little or no effect on houseflies, which are numerous. For about two months after spraying there is also freedom from roaches and ants but they begin to come back slowly thereafter. Cage and panel experiments are now being set up to determine more accurately the exact effectiveness of the treatments.

THE TURLOCK MOSQUITO ABATEMENT DISTRICT of California has had the temerity to issue an Annual Report for 1952 which is so full of a variety of statistics that an adequate review would be impossible, but which should be a boon to anyone seeking figures on the operations and even the costs of such a program for comparison with their own. Tables are given which show complete breakdowns of the total figures in many categories of operations, including costs of materials, operation of vehicles and the salaries of the workers.

FROM RALPH VANDERWORKER (excerpts from a letter to Les Smith): "On Sept. 1, I was assigned to U. S. Coast Guard HQ as Chief Sanitary Engineer Officer located in Room 1202, % HQ at 13th and Penn Ave., N.W.

"The new assignment is very much to my liking. More travel than formerly but near the shores and I enjoy the water as you know. In addition, there is enough field work to keep me aware of current problems.

"So far there have been relatively few mosquito problems. Most of my work involves small water supplies, sewage disposal, food sanitation, plumbing, insect and rodent control."

UTAH MOSQUITO ABATEMENT ASSOCIATION

Districts: Box Elder County, Davis County, Magna, Salt Lake City, South Salt Lake County, Weber County

Sixty per cent of the people in the state of Utah are now living within the boundaries of organized mosquito abatement districts.

For Proceedings of annual meetings and other information write Lewis E. Fronk, Sec.-Treas., Utah Mosquito Abatement Assoc., 2441 Grant Ave., Ogden, Utah

ASSOCIATION NEWS

Treasurer's Report

for period June 5, 1953 to March 5, 1954

Total Receipts as of March 5, 1954		
Dues	\$ 3,887.50	
Advertising	2,152.02	
Reprints	640.25	
Good Neighbor Club	105.00	
Other, including Special Account	4,120.16	
		\$10,904.93
Total Disbursements as of March 5, 1954		
Printing, Mosquito News and Reprints	\$ 5,860.63	
Office Supplies	191.21	
Postage	187.21	
Other	392.77	
Bonds, Ins.	23.75	
		\$ 6,655.57
BALANCE ON HAND, MARCH 5, 1954		\$ 4,249.36
Items in Special Account:		
From sale of exhibit space	\$ 1,000.00	
Registrations (96)	384.00	
Total	\$ 1,384.00	included in total receipts shown above

Respectfully submitted,

Lester W. Smith, Treasurer

The above report is condensed from the report of the treasurer for the better part of the year just past, dating from the time Lester took over from the previous treasurer. It is printed herewith at the request of the treasurer, so that the members of the Association may be brought up to date on our financial condition. Members should be reminded, however, that the "balance on hand" which is apparently very favorable, dwindles very rapidly as each number of *Mosquito News* makes its quarterly inroads on the treasury, so that toward the end of each year we operate very close to the margin. IN OTHER WORDS, PLEASE PAY YOUR DUES PROMPTLY. Do not wait for any deadlines, but please give prompt attention to requests by the treasurer for payment and to any reminders which appear in notices from the secretary or in *Mosquito News*.—D.L.C.

FOR SOME TIME PAST it has been the practice to have extra copies of each issue of *Mosquito News* sent to Walter Henderson, Box 27, Barnegat, N. J. These back numbers are kept by Mr. Henderson for sale to persons who desire to complete their files, such as new members who wish to have a complete set of *Mosquito News*. At the annual meeting held in March in Atlantic City, Mr. Henderson reported that the following issues of *Mosquito News* are either in short supply or have been exhausted:

Vol. 1, #1-2	39 copies	Vol. 10, #1	exhausted
" 1, #4	exhausted	" 10, #2	21 copies
" 3, #1	"	" 10, #3	17 "
" 7, #2	12 copies	" 10, #4	exhausted
" 8, #1	5 "	" 11, #1	"
" 9, #1	8 "	" 13, #2	"

Members and subscribers are urged to inspect this list and if anyone has extra copies of any of those listed, he would be doing the Association a favor by sending them to Mr. Henderson to be added to the stock.

REVIEWS AND ABSTRACTS

INSECTICIDES—MANUAL OF SPECIFICATIONS FOR INSECTICIDES AND FOR SPRAYING AND DUSTING APPARATUS. By The Expert Committee of Insecticides of the World Health Organization. 1953. This is the excellent beginning of what will no doubt be a very useful handbook for all workers in Entomology who are responsible for procurement of insecticides and equipment. Detailed resumes of current standard methods for the chemical analysis of insecticides are given, together with suggested criteria for acceptability in regard to particle size, stability of emulsions, suspensibility of wettable powders, the marking of packages, etc.

A second section includes data on specifications for insecticide dispersal apparatus. This section contains some valuable criteria for judging whether dispersal equipment will be suitably efficient and long lasting. Some of the criteria are set forth without qualification, although they are actually matters of opinion and preference, about which there is not as yet general agreement among field workers. In some instances characteristics appear to be stated in terms of recommendations. The methods of testing strength of the various materials appear to be based upon the excellent, but very rigid tests procedures developed at the laboratories of the U. S. Public Health Service in Savannah. These tests are believed to represent measurements of the highest quality found in commercial practice. Many users may not have facilities for so exacting tests and in practice it may be advisable to provide a wider range of tolerance for some details of construction. The list of definitions for types of sprayers and dusters and for their parts is of great value. It is to be hoped that this long needed publication will be expanded to include definitions of types of "sprays" (smokes, aerosols, fogs, mists, etc.) and similar matters on which there is now little uniformity.

The third section contains excellent figures illustrating some of the analytical apparatus mentioned. These illustrations will no doubt be expanded in future editions. Although the membership of the Expert Committee which compiled the information is of the highest calibre it should be reviewed and perhaps expanded so as to represent a wider field of interest.

The book is loose-leaf and provision is made for the owner to receive additions and amendments, and to make deletions, thus keeping it current as a manual and adding greatly to its usefulness. The material has largely been issued before in separate releases, but is here brought together in readily referable form—W. D. Reed, Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.

(Note: The manual may be purchased for \$8.50 from the Columbia University Press, Inter-

national Document Service, 2960 Broadway, New York 27, N. Y.)

SUSPENSIBILITY OF WATER-DISPERSIBLE POWDER CONCENTRATES USED FOR MALARIA HOUSE-SPRAYING PROGRAMS IN INDONESIA. By Johnson, Donald R. J. Indonesian Medical Assoc., Djakarta, Indonesia 3(5):14 pp. 1953. The testing of water-dispersible powder insecticides for residual spraying in malaria control campaigns is described. The suspensibility of some shipments received in Indonesia has been undesirable because (1) the material was not finely pulverized (2) the formulation may have been inferior, or (3) the product had deteriorated. The writer suggests that the failure of insect control using water-dispersible powder concentrates in various parts of the world, in some instances may have been due to the failure of those doing the work to recognize the poor suspensibility of the products used.

Tests which will enable a person to judge the suspensibility properties in relation to spraying operations are described. Two tests are principally to observe whether or not a water-dispersible powder has good suspensibility. The third test, simulating field operations, will show the relative amounts of wettable powder which are discharged from a sprayer during each minute of spraying time for any particular insecticide used.

Suggestions are made as to how certain unsatisfactory materials can be reconstituted to again make them usable: i.e., by regrinding, by the addition of a wetting agent, or by the use of a knapsack sprayer containing an agitator. Proper storage conditions such as keeping the material in a cool, dry place and the avoidance of excessive pressure on the stored product is emphasized.—Author's summary.

MORPHOLOGICAL STUDIES ON THE COMPOUND EYE IN MOSQUITOES. COMPOUND EYES OF *Culex pipiens* VAR. *pallens* COQUILLETT (No. I); DEVELOPMENT OF THE COMPOUND EYE OF *Culex pipiens* VAR. *pallens* COQUILLETT (No. II); STRUCTURE AND DEVELOPMENT OF THE COMPOUND EYES OF *Aedes (Finlaya) japonicus* THEOBALD (No. III); STRUCTURE AND DEVELOPMENT OF THE COMPOUND EYE OF *Anopheles hyrcanus sinensis* WIEDEMANN (No. IV). By Shôzô Satô. Sci. Repts. Tohoku University (Biol.) 18(3):331-341 (1950); *Ibid* 19(1):23-28 (1951); *Ibid* 20(1):33-44 (1953); *Ibid* 20(1):45-53 (1953). (In English.) These four admirable papers constitute the most complete study we possess of the development of the imaginal eyes in mosquitoes and permit interesting comparisons between three important genera. In *Culex*, *Aedes*, and *Anopheles* the compound

eye develops in either 7 (*Anopheles*) or 9 stages (*Culex* and *Aedes*). In *Culex* the compound eye begins forming in the second instar while in *Aedes* and *Anopheles* it begins development in the third instar. In the first stage of development, the hypodermis thickens and mitotic figures are abundant. The cells thus formed become arranged into groups (stage 2). These groups (future retinula) are surrounded by smaller cells (future iris pigment or accessory pigment cells) in stage 3. Crystal cells form in the center of the future retinula cells and pigment granules appear in the latter (stage 4). In *Culex* and *Aedes*, as pigmentation increases a vacuole-like chamber develops between retinula and crystal cells (stage 5). Most of the iris is occupied by this chamber in *Culex* but not in *Aedes*. There is no vacuole-like chamber in *Anopheles*. Distal and proximal portions of the retinula differentiate into rhabdoms in stage 6. As the vacuole-like chamber enlarges the nuclei of the crystal cells are flattened (stage 7). Stages 1-7 occur in larvae. During the pupal period the eye facets form, the crystal cells enlarge, and the pigment cells thicken (stage 8). In *Aedes* and *Anopheles* oil droplets are present in the retinula. Finally, after adult emergence the lens is completed and the crystal cells form a cone (stage 9). In *Culex* the compound eyes are structurally complete 6-12 hours after emergence but in *Aedes* and *Anopheles* it is not complete for around 24 hours.

Satô found significant differences in the distances between the eyes of adult male and female *Culex* and *Anopheles*, the greatest distance being found in the males. The head width in *Anopheles* was found to be less than in *Culex* or *Aedes*. In the three species studied, the surface area and number of corneal facets were greatest in females. The largest eye facets in all three genera were found on the ventral part of the eye and the smallest facets were found either on the postero-lateral or postero-dorsal surfaces.

Satô compares light-adapted with dark-adapted eyes. In *Culex* as the eye becomes dark-adapted the pigment enters the iris, the lens thickens, the pigment disappears from around the rhabdom, the proximal portion of the retinula narrows. The pupil of the ommatidium becomes greatly enlarged. He found that while the movement of the pigment in both light- and dark-adapted eyes occurs in 10-20 minutes, changes in lens, iris, and retinula were not completed for 2-3 hours (*Culex*). He observed that the pigment in the *Aedes* eye moves outward in the dark-adapted state much less than in *Culex* or *Anopheles*.—Jack Colvard Jones, National Institutes of Health, Bethesda, Md.

MALARIA, PARASITES, TRANSMISSION AND TREATMENT. The London Cinchona Bureau, 10 Storey's Gate, London, S.W. 1. This booklet, chapter 4 of which was published in the Dutch

"Manual of Tropical Medicine" in 1951, is one of the most valuable publications in this field for use by the professional and the layman who work with this disease. On behalf of all those who are unfamiliar with the Dutch language, the London Cinchona Bureau asked the author of the chapter "Treatment of Malaria" and the editors of the Manual for permission to distribute this translation among members of the medical profession in those countries where treatment of malaria constitutes a substantial part of daily routine. The result, a most valuable pocket size booklet about malaria. All pathologists in tropical medicine and especially the malariologists will find the contents to be up-to-date reports which deal with the examination of blood and the treatment of malaria. These data are condensed into a few chapters of pertinent information, illustrated with several excellent plates and accompanied by a Table of Characteristics of different Malaria Parasites in Stained Films. Most interesting to those whose efforts are directed to entomological studies and mosquito biology is Chapter 3 "Malaria Vectors." Malaria vectors of the world are described in relation to various biotypes. Outstanding quality is noted in the full page water colored plates of 24 mosquito adults which are included in this chapter. The colored plates in the chapter on blood examination as well as the tinted plates of mosquitoes are the work of Mrs. B. Bayens who deserves her share of credit for the value of this booklet along with Professor P. B. van Steenis, Professor of Tropical Medicine at the University of Amsterdam, Dr. C. W. F. Winkel, Fellow of the Institute of Tropical Medicine and Geographical Pathology in Amsterdam, and Dr. P. H. van Thiel, Professor of Parasitology at Leyden University whose authority as an expert in the field of malaria vectors is well known. This booklet is highly recommended for use as a ready reference text in the study and teaching of Malariology, not only in the treatment of malaria due to the valuable contents of chapter 4 and the recent developments in malaria treatment, but also to those who are pledged to prevent and control this disastrous disease.—John M. Hirst, U. S. Naval Air Station, Alameda, Calif.

THE ANOPHELINE MOSQUITOES OF THE INDONESIAN AUSTRALIAN REGION. By J. Bonne-Wepster in collaboration with N. H. Swellengrebel. 504 pp. 176 figs. 21 distribution maps. In English. J. H. de Bussy, Amsterdam, Netherlands. Price not given. This is a profusely illustrated and documented descriptive study of the anopheline mosquito species of the Oriental and Australasian Regions. Included within the volume are the following: A description of all morphological characters used in classification, a section on collection and preservation techniques, keys and descriptions of the species, and the distribution (also shown on outline maps) and biology of

each. Figures of adult and larval characters are included for each species.

The authors bring to this considerable task the experience of nearly 35 years of field and laboratory studies in Indonesia. This book is the fourth edition of a work which was first published by Dr. Swellengrebel in 1916.

As a compilation of the enormous literature and as a revision of existing Netherlands' collections this book will admirably serve, as stated by the authors, "the needs of the medical man who has to be a malariologist in out of the way places." From the standpoint of the mosquito taxonomist it is to be regretted that such significant works as Dr. W. V. King's treatment of the Australasian anophelines and Dr. I. M. Puri's account of the Oriental anophelines in volume 1 of Boyd's *Malariology*, 1949, were entirely omitted; and that a number of anopheline species from the treated area (*acaci* Baisas, 1946; *nataliae* Belkin, 1945; *solomonis* Belkin, Knight, and Rozeboom, 1945, among others) were not included. None of this is meant to minimize the

vast volume of detailed material that *has* been included.—Kenneth L. Knight, CDR, MSC, USN, U. S. Navy Preventive Medicine Unit No. 1, NAS, Jacksonville, Florida.

UTILIZAÇÃO DE MOSQUITOS RADIOATIVOS NA AVALIAÇÃO DO RAIO DE VÔO. By Aragao, Mario B. Rev. Brasileira de Malariologia e Doenças Trop. 5(2):137-143. 1953. The author describes a previous experience to verify the possibility of the use of the method of mosquito marking with thorium in the study of the dispersion of the *Anopheles* (*Kerteszia*) spp. in the forest. The larvae were bred in a 1:10,000 thorium nitrate solution. The abdomen of the mosquitoes that were caught was taken out and burned. The identification of the marked mosquitoes was made, on those ashes, with G5 (Ilford) nuclear track plates.

Radioactive mosquitoes were caught in all capture stations. The longest distance in the forest was 800 m.—Author's summary.

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CORRECTION

Vol. 13, no. 3, p. 224, 1953. Dengue. After "Hotta, S. 1953. Dengue epidemics in Japan, 1942-1945," insert, "Jour. Trop. Med. and Hyg. 56(4):83."

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